London Regional Flood Risk Appraisal

Draft

December 2017

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HOW TO GIVE YOUR VIEWS

This draft of the Regional Flood Risk Appraisal is published for public consultation **until 2 March 2018.**

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by email:

londonplan@london.gov.uk with 'Draft Regional Flood Risk Appraisal consultation' in the subject box

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Any representations made in relation to this consultation draft will be made available for public inspection.

Executive Summary

The Mayor is aware that flood risk is a major issue for London, and the probability of flooding is increasing with climate change. The potential consequences of flooding could also increase as London's population continues to grow. The Regional Flood Risk Appraisal (RFRA) provides an overview of all sources of flooding in London and addresses its probability and consequences.

This draft RFRA

- has been prepared by GLA officers in close cooperation with the Environment Agency. Transport for London, London Resilience, and Thames Water have also been involved. It builds on and updates the version that was published in August 2014 to support the Further Alteration to the London Plan
- represents important evidence to underpin the new draft London Plan. The level of detail of data used and the resulting mapping has been greatly improved compared to the previous RFRA, providing better information and evidence for Local Plans, Opportunity Area Planning Frameworks, and infrastructure providers
- includes a revised set of monitoring recommendations, which will be used to ensure regular checks on broad mitigation measures.

Currently 6 per cent of London is at high risk of tidal, river or surface water flooding and 11 per cent at medium risk. At the centre of the RFRA is the spatial analysis of tidal, fluvial and surface water flood risk against a number of different receptors of flood risk.

Looking at the outcomes for Opportunity Areas, Earls Court & West Kensington, the Isle of Dogs and Kensal Canalside have the highest proportion of land in high flood risk areas (all just over 15 per cent) and for Town Centres it is Kingston (34 per cent) and Woolwich (27 per cent). For all Opportunity Areas individually this RFRA includes potential mitigation measures and also raise relevant flood risk issues for all Town Centres to be addressed locally.

The highest percentages in terms of the number of strategic infrastructure assets in high flood risk areas apply to utility sites (44 per cent of 587 sites), hospitals (43 per cent of 191 sites) and waste sites (34 per cent of 312 sites). But it should be recognised that this is a precautionary approach. Sites in the central/inner London Thames tidal floodplain have a high degree of tidal flood protection. Also, many of these sites are large complex building structures, and without further analysis it is very difficult to know, if important parts that could put people or the operation of the infrastructure at risk might be affected. In many cases it may only be small areas. All other infrastructure assets such as transport routes and stations, emergency services and schools have lower proportions for high flood risk.

The flood risk and drainage policies in the new draft London Plan are to a large degree focused on the mitigation of flood risk. They require to sustainably manage flood risk through new development, e.g. through improved management of surface water, setting development back from the waterways and allowing space for future maintenance and upgrade of flood defences. Policy SI12 also includes a specific reference expecting that utility services should be designed to remain operational under flood conditions and that buildings should be designed for quick recovery following a flood.

Chapter 1 - Introduction

1. Chapter 1 deals with the strategic overview of flood risk in London with particular reference to the London Plan. Chapter 2 deals with a more detailed analysis of the risk from all six types of flooding that could affect London. Chapter 3 then examines flood risk in relation to particular locations, boroughs and important infrastructure. Appendix 3 provides the related maps and detailed statistics.

1.1 Wider Policy Background

2. The issue of flood risk has become increasingly recognised over recent years with much publicised floods in winter 2014, late summer 2015 and early summer 2016.

3. One of the key elements of Planning Policy Statement 25 (PPS 25) and its Practice Guide introduced in 2006 was a **flood risk appraisal hierarchy**, with developers/landowners producing site-specific Flood Risk Assessments (FRAs) and local authorities producing Strategic Flood Risk Assessments (SFRAs). These are currently being updated by many London boroughs. For Greater London, with its 33 local authorities, a Regional Flood Risk Appraisal (RFRA) with a broad consideration of flood risk across London's borough boundaries represents important evidence to underpin the London Plan and should also inform local-level flood risk assessments and Local Plans. As flood risk is a strategic issue, the RFRA also facilitates the application of the Duty to Cooperate beyond London's boundaries including the authorities upstream along the River Thames and downstream of London in the Thames Estuary.

4. The **National Planning Policy Framework** (NPPF)[1] and the Planning Practice Guidance on Flood Risk and Coastal Change[2] set out the currently relevant planning requirements at national level. They retain the importance of flood risk management considerations that had been introduced through the PPS25.

5. In London, the boroughs are **Lead Local Flood Authorities** (LLFAs) and are responsible, in particular, for local surface water flood risk management and for maintaining a register of flood risk. They identify areas of flood risk to help inform appropriate locations for development. The GLA-led Drain London project has over recent years significantly improved the understanding of surface water flood risk across London.

6. The Environment Agency's Thames River Basin District **Flood Risk Management Plan**[3] is part of a collaborative and integrated approach to catchment planning for water. It has drawn on evidence set out in the Thames Catchment Flood Management Plan[4]. Making space for water when considering development proposals is particularly important where there is significant exposure to flood risk along tributaries and at the tidal-fluvial interface.

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[1] www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf - see in particular paragraphs 100 - 104

[2] www.gov.uk/guidance/flood-risk-and-coastal-change

[3] For details see www.gov.uk/government/publications/thames-river-basin-district-flood-risk-management-plan

[4] For details See Section 2.2 on fluvial flood risk

7. The **Thames Estuary 2100 Plan** (TE 2100) was published by the Environment Agency and endorsed by Government in November 2012. It addresses flood risk specifically from the tidal Thames and requires the ability to maintain and raise some tidal walls and embankments. The Environment Agency undertook a five-year Interim Review of the TE2100 Plan in 2016 and found it to be broadly on target[5]. A more comprehensive ten-year Review will commence in 2018 and published in 2020. The TE2100 Plan introduces the concept of Riverside Stratgies to improve flood risk management in the vicinity of the river, create better access to and along the riverside, and improve the riverside environment. These will be collaborative documents and the GLA will support their production.

8. This review deliberately crosses the boundary between land use planning and **emergency planning**. This recognises the need for close liaison between the two disciplines. The London Resilience Team has published its London Resilience Partnership Strategy[6] in 2016. This seeks to co-ordinate emergency services and emergency planners across London in the event of a major flood. In addition, in 2015 the London Strategic Flood Response Framework[7] was updated and includes greater consideration of social drivers of vulnerability to flooding (not just modelling data) and a more proactive response arrangement across the resilience partnership.

9. The **scale and distribution of flood risk** is shown on Map 1 included in Appendix 3: Currently 6 per cent of London is at risk of tidal, river and surface water flooding for a 1 in 30 year event[8] (high risk) and 11 per cent for a 1 in 100 year event[9] (medium risk). In chapter 3 these flood risk areas will be intersected with a number of different receptors of flood risk, including growth areas, infrastructure assets and services. The underlying Environment Agency data combine flood risk from rivers, the sea and surface water. Further updates of the surface water flood risk component will be included when new local data from LLFAs become available.

10. In spring 2016 the Government published **revised climate change allowances**[10]. They consider the lifetime, vulnerability and location of a development. Therefore, the assessment of London's Opportunity Areas, as key locations for future growth, does not only consider 1 in 30 and 1 in 100 year events (high and medium risk), but also 1 in 1000 year events (low risk). This precautious approach was agreed with the Environment Agency as an appropriate reflection of the revised allowances.

1.2 The London Plan

11. The RFRA represents important evidence to underpin the new draft London Plan. Flood risk should be recognised as an important consideration as part of all development proposals and in combination with the NPPF and its associated Guidance, Policy SI12 sets out the following **strategic approach** in London.

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[5] For details see https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/558630/TE2100_5_Year_Review.pdf

[6] For details see www.london.gov.uk/sites/default/files/london_resilience_partnership_strategy_2016.pdf

[7] For details see www.london.gov.uk/about-us/organisations-we-work/london-prepared/planning-emergencies-capital#acc-i-43126

[8] Greater than 3.3 per cent chance of flooding in any year

[9] Greater than 1 per cent chance of flooding in any year

[10] For details see www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Policy SI12 Flood risk management

A Current and expected flood risk from all sources across London should be managed in a sustainable and cost effective way in collaboration with the Environment Agency, the Lead Local Flood Authorities, developers and infrastructure providers.

B Development Plans should use the Mayor's Regional Flood Risk Appraisal and their Strategic Flood Risk Assessment as well as Surface Water Management Plan, where necessary, to identify areas where particular flood risk issues exist and develop actions and policy approaches aimed at reducing these risks. Boroughs should co-operate and jointly address cross-boundary flood risk issues including with authorities outside London.

C Development proposals which require specific flood risk assessments should ensure that flood risk is minimised and mitigated, and that residual risk is addressed. This should include, where possible, making space for water and aiming for development to be set back from the banks of watercourses.

D Developments Plans and development proposals should contribute to the delivery of the measures set out in Thames Estuary 2100 Plan. The Mayor will work with the Environment Agency and relevant local planning authorities, including authorities outside London, to safeguard an appropriate location for a new Thames Barrier.

E Development proposals for utility services should be designed to remain operational under flood conditions and buildings should be designed for quick recovery following a flood.

F Development proposals adjacent to flood defences will be required to protect the integrity of flood defences and allow access for future maintenance and upgrading. Where possible, development proposals should set permanent built development back from flood defences to allow for any foreseeable future upgrades.

12. As a significant measure to address in particular surface water flooding Policy SI13 on Sustainable Drainage is quoted below as well. The well-established **Drainage Hierarchy** is at its centre the policy It will help to reduce the rate and volume of surface water run-off. Rainwater should be managed as close to the top of the hierarchy as possible. The role of blue roofs is specifically highlighted in the new policy. They can be green roofs engineered to retain water or attenuation tanks at roof or podium level. The combination of a blue and green roof is particularly beneficial as the attenuated water is used to irrigate the green roof.

13. Over recent years the scale of sustainable surface water management measures in major planning applications in line with this policy has increased significantly. Many such applications achieve the greenfield run-off rate the policy is aiming at. It is expected that relevant measures are less common on smaller scale developments but are becoming more commonplace as LLFAs are now well established in their roles.

Policy SI13 Sustainable drainage

A Lead Local Flood Authorities should identify – through their Local Flood Risk Management Strategies and Surface Water Management Plans – areas where there are particular surface water management issues and aim to reduce these risks.

B Development proposals should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible in line with the following drainage hierarchy:

1) rainwater harvesting (including a combination of green and blue roofs)
2) infiltration techniques and green roofs
3) rainwater attenuation in open water features for gradual release
4) rainwater discharge direct to a watercourse (unless not appropriate)
5) rainwater attenuation above ground (including blue roofs)
6) rainwater attenuation below ground*
7) rainwater discharge to a surface water sewer or drain
8) rainwater discharge to a combined sewer.

C Development proposals for impermeable paving should be refused where appropriate, including on small surfaces such as front gardens and driveways.

D Drainage should be designed and implemented in ways that address issues of water use efficiency, river water quality, biodiversity, amenity and recreation.

* The benefit of attenuation above compared to below ground or in a basement is that pumping is normally not required to empty the attenuation tank.

14. Other draft London Plan policies are also relevant, including Policy SI5 about Water Infrastructure. Its supporting text says that **Integrated Water Management Strategies** should be considered for major development locations such as Opportunity Areas, where flood risk alongside water-related constraints require an integrated approach to the provision of infrastructure and management of risk.

15. A **Water Advisory Group** has been established to advise the Mayor on strategic water and flood risk management issues.

1.3 The Sequential Test

16. The NPPF contains a Sequential Test[11] to ensure that development takes place in the areas available at lowest flood risk.

17. London is heavily built up with a tightly drawn administrative boundary. The delineation of the Green Belt and the other protected open spaces in London mean that the scope for new development on land other than brownfield redevelopment land is extremely limited. Over recent years the vast majority of new development has taken place on **brownfield land**[12]. This trend is expected to continue. Many of London's

[11] Para 101

[12] For details see Key Performance Indicator 1 of the Annual Monitoring Report

remaining large brownfield areas are either substantially or partially at risk of flooding, including some Opportunity Areas[13].

18. The latest **Strategic Housing Land Availability Assessment** (SHLAA)[14] examined the potential housing capacity within London to inform the London Plan. Flood risk was considered as an important environmental constraint, and this approach reflects a strategic approach to the sequential test. Sites with a known flood risk had their capacity reduced depending upon the severity of the risk. In the SHLAA methodology Flood Zone 3b sites were considered to be unsuitable and by default to have zero probability for housing. Sites in Flood Zone 3a had their probability reduced by 10 or 5 per cent respectively depending on the existence of flood defences. The boroughs had then the opportunity to adjust the probability reduction based on their SFRAs, any specific surface water flood risk issues and potential mitigation measures.

19. The anticipated growth is planned to be accommodated in particular in London's **major development locations** and town centres, where individual risks will have to be looked at by the London boroughs in more detail. They and developers will still need to apply the sequential test locally and consider flood risk assessments at a more detailed level when allocating uses or applying for planning permission. It will also remain important to place more vulnerable uses in areas with lower flood risk in order to meet the Sequential Test at a local level.

20. For development that cannot be located in lower flood risk areas, the **Exceptions Test** can be applied[15]. It requires that a development can demonstrate wider sustainability benefits and is safe over its lifetime.

1.4 How to use the RFRA

21. The RFRA is a strategic overview of flood risk across London. It does not represent a detailed analysis of flood risk in relation to any particular areas or sites. It contains a series of maps to illustrate flood risk spatially (see Appendix 3).

22. It also includes a series of **recommendations** (see Appendix 1), for example related to improvements to local flood risk policies and Drain London activities. The recommendations are meant as a monitoring tool and progress against them will continue to be reported annually in the London Plan Annual Monitoring Report.

23. **Future updates** of the RFRA should take place approximately every five years or after a major flooding incident or a major policy shift.

24. The RFRA should be useful to spatial planners, developers, infrastructure and utility operators and emergency planners. It is a specific aim of this RFRA to give spatial planners and emergency planners a **shared understanding** and common baseline of information.

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[13] For details see Map 2

[14] The full SHLAA is available on the London Plan Evidence website https://www.london.gov.uk/what-we-do/planning/london-plan/london-plan-full-review/full-review-evidence-base

[15] See para 102 of the NPPF

Chapter 2 - Overview of Flood Risk

25. London is exposed to six different potential sources of flooding. These are analysed below, each has different spatial impacts on London and requires a different set of responses. Some responses relate to the land use planning system, whilst others relate to broader spatial matters or operational considerations for a range of organisations.

26. Each type of flooding is analysed by examining:

- Nature of the risk
- Development locations that may be affected
- Information available
- Broad flood risk management options
- The likely impact of climate change
- Strategic recommendations

27. Chapter 3 goes on to consider flood risk in relation to key locations and infrastructure in London. In this way the RFRA represents an examination of both the potential future flood risk issues and the existing flood risk issues that affect London. By doing this it can make recommendations that fulfil one of two functions. Firstly, how to ensure that future flood risk is minimised and any residual flood risks are managed appropriately. Secondly, to promote new development that will help to reduce and manage existing flood risks. This approach is in line with the NPPF.

2.1 Tidal Flood Risk

Nature of Risk

28. The River Thames and the lower reaches of some of the tributary rivers are affected by the tide. The River Thames has a very large tidal range, in excess of 7 metres on spring tides. The **tide's influence** reaches to Teddington Lock on the Thames and up several tributaries, for example as far as the Prescott Channel structure on the River Lee.

29. Without the current **river walls** many areas of London alongside the Thames and along the tidal stretches of the tributaries would be inundated twice a day through the normal tidal cycle. River walls have been steadily built up since Roman times to give increasing levels of flood protection and to enable urban development.

30. The particular threat that has remained is from **tidal surges**. These occur when a combination of high tide, easterly winds and a weather system depression over the North Sea can cause the tide levels to increase significantly above the normal tidal range. Previous incidents of this type of flood risk date back to 1236. More recently, in 1928, 14 people were drowned in Westminster; this was the last time that central London suffered tidal flooding. In 1953 London was largely spared the impacts of a devastating tidal flood that cost the lives of over 300 people in the East of England. The most recent tidal surge in 2013/14 particularly affected the outer Thames Estuary. If any of those floods had funnelled further up the Thames, the results for the capital could have been even more disastrous.

31. As a result of the 1953 flood, a **system of flood defences** was constructed. The most iconic element of this is the Thames Barrier, which has been operational since 1982. There are also around 400 smaller barriers and movable flood gates downstream of the Thames Barrier and over 300 km of river walls and embankments stretching into Essex and Kent that have been raised by 2 metres to give additional protection from storm surges. Upstream of the Thames Barrier river walls are still necessary to prevent the normal range of high tides from flooding parts of inner and central London. This system of tidal flood defences made allowance for sea level rise and London is therefore protected to a very high level. It is estimated that further measures will be needed after 2030 to maintain a 1 in 1000 year risk level.

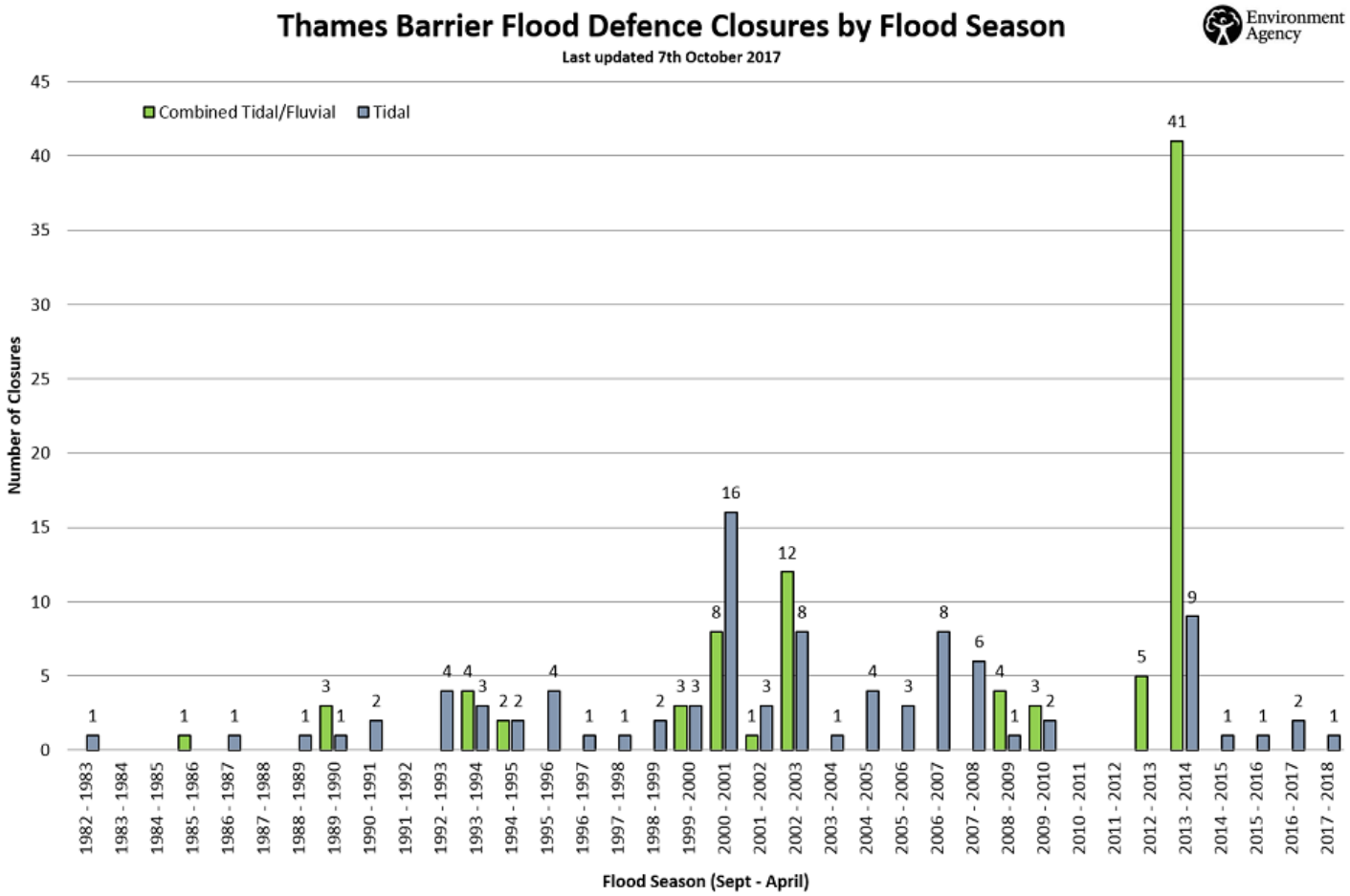
32. Since its completion in 1982, the **Thames Barrier** has been closed 179 times to prevent flooding[16]. Of these closures, 92 were to protect against tidal flooding and 87 were to protect against combined tidal/fluvial flooding. Diagram 1 indicates that the number of closures per year is fairly variable. However, there is a general increase in the number of closures with a recent peak in the winter 2013/14, which saw a record number of 50 closures and triggered an investigation by the Environment Agency. It concluded that it is too early to identify whether or not this peak was part of an emerging longer-term trend, but it is not part of an existing trend[17]. The Environment Agency continues to estimate that a new Thames Barrier is likely to be required towards the end of the century. Potential sites will be needed in Kent and/or Essex requiring close partnership working with the relevant local authorities.

33. It should be noted that closures of the Thames Barrier also necessitates closure of other barriers and flood gates, and it prevents navigation through the Barrier.

[16] For further details see www.gov.uk/guidance/the-thames-barrier

[17] TE2100 5 Year Review (Environment Agency), page 4 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/558631/TE2100_5_Year_Review_Non_Technical_Summary.pdf

Diagram 1



Source: Environment Agency

34. There are **residual risks** even given the high standard of flood risk management measures that are in place. These risks are:

- from an overtopping of the defences, i.e. a larger event than has been planned for, or
- from a breach in the defences, i.e. a failure, either accidental or deliberate, of the defences.

35. The likelihood of such residual risks is very small. However, the scale of consequences from rapid inundation and deep water in heavily urbanised areas mean that these residual risks must be considered. **Management and mitigation** of residual risks in defended parts of London along the tidal Thames are a notable component of site-specific FRAs, with the approach to residual risk depending largely on surrounding ground levels and the type of land use proposed.

Locations

36. The tidal flood risk area through London affects areas to the north and south of the Thames and up some of the tributary rivers. Given that much of the land alongside the Thames in **central and inner London** has been in active urban use for centuries, there is a lot of infrastructure already in place, and protection is of a high standard through the combination of flood walls and embankments, the Thames Barrier and other movable gates and barriers.

37. In north east and south east London there are large areas of derelict or under-used land forming the **Thames Gateway**. These areas have mostly been in industrial uses, many of which have now ceased or are declining. These areas make up some of the major opportunities for London to accommodate its own growth pressures. Being alongside the river it is to be expected that many of these areas will have an associated element of flood risk.

Information available

38. The Environment Agency **Flood Zone mapping** is integrated into a mapping tool on the Environment Agency website[18]. It includes the 1 in 1000 (0.1%) tidal flood risk envelope and covers a wide area and is closely related to the 5m land contour.

39. The **condition of flood defences** is held on a database by the Environment Agency which carries out regular visual inspections to update condition surveys and take appropriate action either directly or through riparian owners to ensure that structures are in a sound condition. The vast majority of flood defences along the Tidal Thames are in a good structural condition.

40. It should be noted that shortly before this RFRA was published, comprehensive **breach modelling** was released by the Environment Agency for the tidal Thames between Teddington and the Thames Barrier. It was not possible to include this within the current RFRA but should be used when completing a detailed analysis of flood risk in relation to any particular areas or sites. The Environment Agency are also in the

[18] See https://flood-warning-information.service.gov.uk/long-term-flood-risk/map, and more detailed tool for planning applications,which e.g. also includes areas benefitting from flood defences and flood storage areas https://flood-map-for-planning.service.gov.uk/

process of reviewing the breach modelling for the area downstream of the Thames Barrier, and this will be published in early 2018.

Flood Risk Management Options

41. Flood defences for the Thames Estuary have been built up over hundreds of years and have tended to respond to flood events by successively raising the height of flood defences walls and embankments. The current **system of defences** were last upgraded based on the knowledge of sea-level rise in the 1970s and 1980s and in response to the tidal surge of 1953 and includes the Thames Barrier. The TE2100 Plan, which for the first time plans for future flood risk management in anticipation of future flood risk rather than in response to a flood event, indicates that the present system of flood risk management for tidal flooding can continue to provide an acceptable level of risk management up to 2030 without major alterations. **Beyond 2030 more actions** will be needed to maintain the 1 in 1000 year risk (0.1%). Some further details from the Environment Agency's **TE2100 Plan** are set out below:

2012 – 2035:

- Work with Local Authorities and the construction industry to ensure that existing and new development is safe through spatial planning and local resilience measures
- Prepare joint riverside strategies establishing a shared vision for the riverside
- Continue to maintain, enhance, improve or replace existing flood management systems
- Work with Local Authorities and communities on the future use of the Thames Barrier in managing fluvial flooding in West London
- Continue flood forecasting and emergency planning activities
- Commence the creation of new inter-tidal habitat in the Lower Estuary which is being lost as sea levels rise

2035 – 2070:

- Maintain, improve or replace the walls, embankments, barriers and gates along the Estuary
- Work with Local Authorities and communities on enhancing and revitalising the Thames riverside
- Continue flood forecasting and emergency planning activities
- Continue replacing areas of inter-tidal habitats as sea-levels continue to rise
- Decide on and construct the option to manage increasing flood risk for the end of the Century and beyond

2070 – 2100:

- End of the century option operational (see 2035-2070).
- Further raising and adaptation of defences where required to keep new Barrier closures to within operational arrangements
- Continue programme of maintenance replacement and repair of upstream and downstream defences
- Continue flood forecasting and emergency planning activities

42. These actions will be easier, more affordable and more sustainably delivered, if they are planned for from today. So, the Environment Agency is beginning to explore how to

deliver them in collaboration with its partners[19]. The Environment Agency has also identified four broad areas (Reaches) of the Thames and has outlined the following general spatial options. It will be important for SFRAs and new developments to identify methods of implementing these options:

West London Reach (Teddington Lock to Hammersmith Bridge)
43. Pursue alternative responses to managing fluvial risk such as flood resilience measures (e.g. flood gates) or potentially safeguarding land for future flood storage on the fluvial tributaries and setting back of development from river walls to enable river walls to be modified, raised and maintained in a sustainable, environmentally acceptable and cost effective way.

City Reach (Hammersmith Bridge to Thames Barrier)
44. Pursue options for small scale set back of development from river walls to enable river walls to be modified, raised and maintained in a more sustainable, environmentally acceptable and cost effective way.

Regeneration Reach (Thames Barrier to Tilbury Docks)
45. Pursue options for small scale set back of development from river walls to enable river walls to be modified, raised and maintained in a more sustainable, environmentally acceptable and cost effective way. In some cases there may be opportunities for larger scale set back as part of development in the Thames Gateway.

46. Large areas of currently undeveloped land such as Rainham/Wennington Marshes, Erith Marshes and Dartford/Crayford Marshes could potentially be used as strategic locations to increase available flood storage. It may be appropriate to consider ways to safeguard such land for future flood risk management uses or habitat creation.

Lower Estuary Reach (Tilbury Docks to Southend)
47. This is outside London but options sited here could protect London. This area may provide environmental mitigation and compensation for impacts inside London.

Confluences
48. Particular care will be needed when examining the confluences of tributary rivers with the Tidal Thames given the interaction between the different systems[20]. There may be particularly severe effects when a high tide combines with peak fluvial flows. In general the flood defences have been built to a very high standard and therefore these areas share high levels of flood protection.

The Likely Impact of Climate Change

49. Climate Change will have a major impact on the tidal flooding threat. The rising sea level will steadily reduce the level of protection that defences offer. The TE2100 5 Year Review undertaken by the Environment Agenchy in 2016 confirmed that sea level rise is taking place 'within the bounds' of what the TE2100 Plan expected[21]. The predictions for how quickly sea level will rise vary considerably depending on the assumptions used

[19] For further details about the TE2100 Implementation Plan please contact te2100@environment-agency.gov.uk
[20] This influence can stretch several miles upstream of the confluence
[21] For details see https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/558630/TE2100_5_Year_Review.pdf

about emissions and climate modelling: Up to 2030 there are limited differences between predictions, and existing flood risk management options can continue to provide appropriate risk management for tidal flooding. Beyond 2030 there is more variation in the projections, and it is important that the close monitoring of sea level rise continues.

Recommendation 1 – Tidal Flood Risk
The London boroughs should address relevant tidal flood risk mitigation measures set out in the Thames Estuary 2100 Plan in their Local Plans. They include setting back development and defences from the banks of watercourses, flood storage and flood gates.
The delivery of Riverside Strategies through Thames Estuary 2100 should be supported.

2.2 Fluvial Flood Risk

Nature of Risk

50. London has many tributary rivers leading to the River Thames and the Thames itself is a fluvial river upstream of Teddington Lock. As with any river system there is a possibility that any of these rivers could flood. This could come from either particularly intense rainfall within the catchment or from a blockage or restriction to flow within the river channel.

51. The Environment Agency has produced **Catchment Flood Management Plans** (CFMPs) for fluvial rivers in England and Wales. These CFMPs examine the characteristics of rivers, current and future flood risk and potential flood risk management measures and set out a long-term view of flood risk (50-100 years). The CFMPs relevant to London are:

- Thames CFMP – December 2009[22]
- North Kent Rivers CFMP – September 2008

52. As a predominantly urban area London's rivers are often heavily modified from their natural state. This means that rivers have been straightened, deepened, widened and constructed from materials such as concrete. These changes have often been made specifically to reduce the risk of flooding by either increasing the physical size of the river channel or increasing the rate at which it can convey water.

53. The **urbanised river environment** also contains many bridges, tunnels and culvert structures. These culverts are often underneath roads or railways but sometimes also flow under substantial areas of built up land. These form potential flood risks as they can become blocked or restricted through fallen tree branches, litter or larger debris such as shopping trolleys, mattresses or even vehicles. Culverts present a particular difficulty in that it is difficult and expensive to determine their condition and to carry out maintenance and repairs. It can also be difficult to ascertain ownership and maintenance responsibility for some culverts. It is also known that there are a significant number of illegal mis-connections of foul sewers to surface water drains, which lead to ongoing pollution of rivers. In general, opportunities to remove and open up culverts should be taken on environmental and aesthetic grounds as well as in order to improve

[22] The Thames Flood Risk Management Plan, which was produced more recently in March 2016, has drawn on the evidence and proposals set out in this CFMP, but has not replaced it.

flood risk management. This is also addressed in the new draft London Plan Policy SI17 on waterways protection.

54. In London the rate at which rainwater enters urban rivers is significantly higher than normally occurs naturally. This is because a larger proportion of London's surface is covered by hard impermeable surfaces, which are positively drained via surface water sewers into local watercourses and then to larger tributaries. This also increases the absolute volume of rainwater that reaches rivers because there is less chance for water to soak into the ground, be taken up by vegetation or evaporate.

55. Such urban rivers respond very rapidly to rainfall and the opportunity for flood warnings can be as short as 30 minutes. Some larger rivers such as the Lee or the fluvial Thames have much bigger upstream catchments so flood flows can be detected several hours or even days in advance, allowing for reasonable flood warnings to be issued.

Canals

56. London has many miles of canals. In general, canals pose a low flood risk, as they have limited surface water inputs. However, the Grand Union Canal is linked to large fluvial catchments - including the Colne Valley, the River Lee Navigation, and the River Brent - and may convey flood waters from fluvial sources. A further consideration is that any canal, which is on land higher than the surrounding land, has the potential for a breach. Therefore, consideration of flood risks from canals needs to be factored into SFRAs and FRAs.

Locations

57. Fluvial flooding affects parts of most London boroughs. As such it affects a number of Opportunity Areas, town centres and strategic infrastructure across the city. In general, the scale of risk is more localised than for tidal flooding. Fluvial flooding has been more frequent than tidal flooding meaning that many areas of floodplain have been left un-developed, often forming parks within the wider urban setting, which should be protected. The most prominent example is the Lee Valley Regional Park.

Information available

58. The Environment Agency produced and regularly updates its Flood Zone maps, which are integrated into the mapping tool on the Environment Agency website[23]. There are also detailed floodplain modelling for some of the tributaries. Most tributaries have been modified to reduce the likelihood and severity of flooding. In many cases these consist of raised river walls and widened channels. In the case of the River Lee an entire new flood relief channel was constructed along the east side of the Lee Valley in the 1970s. These channel modifications have generally resulted in a reduction of biodiversity value and amenity value and an increased maintenance requirement.

59. The CFMPs **classify floodplains** into 6 broad types:

- Undeveloped natural floodplain

[23] See https://flood-warning-information.service.gov.uk/long-term-flood-risk/map, and more detailed tool for planning applications,which e.g. also includes areas benefitting from flood defences and flood storage areas https://flood-map-for-planning.service.gov.uk/

- Developed floodplain with no built defences
- Developed floodplain with built defences
- Developed floodplain with typically concrete river channels
- Major urban expansion in or close to floodplains
- Narrow floodplains and mixed use land

60. The CFMPs then identify five policy options to manage flood risk and the key messages that are relevant to each of these approaches.

61. These approaches are applied to **policy units** (sub-regional areas) that have been identified by geography, floodplain characteristics and land use types. More detailed actions for each policy unit, reflecting the relevant approach, have been identified to manage flood risk, today and in the future. These actions can be split into two types: those that help to reduce the likelihood of flooding occurring and those addressing the consequences if a flood does happen.

62. Three of the five policy options are used in London and they are specified below in relation to each of the catchments. SFRAs and FRAs should consider how to implement these policy approaches in local circumstances.

London Catchments *(local authorities in italics are outside London but relevant to the management of the catchment)*

63. Each tributary river system in London has different attributes, these are described below:

River Lee - Boroughs affected: Barnet, Enfield, Waltham Forest, Haringey, Hackney, Tower Hamlets, Newham

64. The River Lee catchment is a mixture of relatively small urban tributaries with very fast reaction times to flood and the main River Lee channel which has a large and substantially rural upstream catchment. The River Lee suffered extensive flooding in 1947 as a result of rapid snowmelt. In the 1970s the River Lee Flood Relief Channel was completed to reduce the risk of flooding through the Lee valley. It is known that the design specification for the River Lee Flood Channel was to accommodate a 1 in 75 flood (1.3% chance of flooding in any year). This is below the level of protection that is now required for development under the NPPF. Furthermore the level of protection is likely to have been reduced further by the extensive development in the Hertfordshire and west Essex upper catchment of the River Lee. It will therefore be important for the current level of flood protection through the Lee Valley to be re-assessed. This is particularly relevant given the extent of built development (including raised reservoirs) in the natural floodplain and the fact that there are considerable development proposals both within and outside London.

65. The Lee catchment also includes several tributaries which have experienced localised flooding, notably Salmons Brook, Ching Brook, Turkey Brook and Pymmes Brook. These are all highly urbanised catchments where flood risk needs to be addressed strategically. The Environment Agency has recently completed the construction of a flood alleviation scheme for Salmons Brook that, together with maintenance of the existing river structures, reduces the risk of flooding significantly.

66. The CFMP recommends an approach to take further action to reduce the risk of flooding for the main River Lee river channels. For the tributaries of the Lee the CFMP recommends taking action to increase the frequency of flooding on open spaces to deliver benefits locally or elsewhere, which may constitute an overall flood risk reduction.

67. The Environment Agency has published a document summarising the findings of the Lower Lee Flood Risk Management Strategy. This covers the fluvial River Lee from Hertford to the Queen Elizabeth Olympic Park, including the tributaries of the River Lee, and outlines the proposals for managing fluvial flood risk in the catchment.[24]

River Roding - Boroughs affected: Barking & Dagenham, Redbridge, Newham

68. The river here was extensively re-engineered during the 1980s and 1990s in conjunction with the construction of the North Circular Road and M11 and the introduction of a semi-tidal barrage in Barking. There has been localised flooding within London in recent years although most regular flooding occurs on agricultural land north of the London boundary. The Environment Agency's River Roding Flood Risk Management Scheme provides a strategic perspective on flood risk in the Roding catchment[25].

69. For the London reaches of the River Roding, the CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

River Rom/Beam - Boroughs affected: Barking & Dagenham, Havering

70. There has been limited localised flooding in this catchment and the Beam wetlands serve as a strategic flood storage area. Development proposals will still need to consider their flood risk.

71. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

River Ingrebourne - Boroughs affected: Havering, Brentwood

72. There has been some localised flooding to properties in Upminster and other flooding on open spaces through the river valley of this relatively natural tributary. There is also the tidal interaction where the southern part of the river becomes tidelocked at high tide.

73. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

River Brent - Boroughs affected: Barnet, Brent, Harrow, Ealing, Hounslow

[24] For details see www.environment-agency.gov.uk/research/library/consultations/54262.aspx
[25] For details see www.environment-agency.gov.uk/homeandleisure/floods/148706.aspx

74. The River Brent and its various tributaries have suffered localised flooding, particularly in the upstream catchments of Harrow, Brent and Barnet. The Environment Agency is examining options in partnership with the London boroughs of Brent and Harrow and Thames Water to address this. These options will then be examined and recommendations will be taken forward by the partners. These recommendations will need to inform local policy objectives to reduce and store surface water run-off. This can be achieved through Local Plan policies, updates to SFRAs and development of Local Flood Risk Management Strategies. The Brent flows through extensive park areas offering opportunities for flood risk management and the enhancement of the river corridor. The Wealdstone Brook and the Colindale Flood Alleviation Schemes are investigating options to alleviate the risk of flooding in these areas in particular[26].

75. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

River Crane - Boroughs affected: Harrow, Hillingdon, Ealing, Richmond, Hounslow

76. This river has historically suffered flooding problems in its lower reaches. The upper Reaches, known as the Yeading Brook, flow through considerable lengths of parks and open spaces giving some less sensitive areas for floodwater to be accommodated. Nevertheless a strategic examination of options for sustainable surface water management, bearing in mind climate change predictions, should be used to influence future development decisions and considerations of the management of the riverside open spaces.

77. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

River Colne and Pinn - Boroughs affected: Harrow, Hillingdon, *Spelthorne*

78. The Colne is a large tributary which in places forms London's western boundary. It has suffered extensive flooding in the past, although mostly of undeveloped land. Flood alleviation works have been undertaken. The River Pinn has had several recorded localised floods over recent years. There are Environment Agency projects investigating options to alleviate the risk of flooding on the River Pinn and the Lower Colne[27].

79. For the River Colne, the CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change) and for the

[26] The Wealdstone Brook Scheme is a partnership project between the London Borough of Harrow, Environment Agency and Thames Water. There are historical flooding issues, particularly due to the foul sewerage system backing up as a consequence of being overloaded with surface water. The project is looking at the scope of opening up a culvert and creating flood storage as part of a development site in the Wealdstone Brook catchment, but it is also looking at other options such a flood storage areas. The current estimated completion date for this project is 2022. The Colindale Scheme is looking at options for local flood storage areas aiming to be completed in 2025.

[27] The project for the River Pinn catchment is looking at the effect that maintenance of vegetation has on river flows, also to increase the resistance and resilience of the communities in the catchment. The project is expected to be completed by 2023. Along the Lower Colne there are a range of projects looking at maintenance and potential flood storage areas.

Pinn it recommends taking action to increase the frequency of flooding on open spaces to deliver benefits locally or elsewhere, which may constitute an overall flood risk reduction.

Hogsmill River - Boroughs affected: Kingston, *Epsom & Ewell*

80. Some localised flooding has occurred on this river, notably through Kingston Town Centre. Most of the route of the river flows through open spaces and parts of the Green Belt. The Hogsmill is characterised by a developed floodplain with typically concrete river channels. The risk of flooding in these areas is relatively high and it is likely that this will increase in the future. Flooding caused by surface water, overflowing drainage systems, and the systems themselves, are the responsibility of several organisations.

81. The CFMP recommends taking action to increase the frequency of flooding on open spaces to deliver benefits locally or elsewhere, which may constitute an overall flood risk reduction.

Beverley Brook - Boroughs affected: Richmond, Wandsworth, Kingston, Merton.

82. Many parts of the floodplain remain as open space, notably through Richmond Park, although the Raynes Park area is identified as having an extensive floodplain. This coincides with the confluence of two tributaries and the river passing underneath several major road and railway structures.

83. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

River Wandle - Boroughs affected: Wandsworth, Merton, Sutton, Croydon.

84. The downstream area of this river catchment runs through a heavily built up area with floodplain covering significant areas of already developed land. Some upstream areas south of Mitcham are more open with some storage of floodwater possible.

85. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

River Ravensbourne - Boroughs affected: Lewisham, Bromley, Greenwich

86. This is a relatively large river with several tributaries. In the downstream reaches the river is tightly confined by urban development although in the more southerly upstream reaches the river and its tributaries often flow through open spaces. Parts of the river system have benefited from river restoration projects in recent years, which have also improved flood risk management. The Environment Agency is also investigating a flood defence scheme in the Catford/Lewisham reaches of this river.

87. The CFMP recommends an approach to take further action to prevent an increase in flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

River Cray/Darent - Boroughs affected: Bexley, Bromley, Greenwich, *Dartford*

88. The upstream reaches stretch out into the Green Belt. Through much of the middle reaches the river runs through a mix of built up areas and open space and in the lower reaches there are extensive areas of floodplain and the interaction with the tidal Thames presents a further flood risk although the Dartford Barrier controls this risk with Dartford and Crayford Marshes providing large areas of flood storage upstream of the Barrier

89. These catchments are covered by the North Kent Rivers CFMP which recommends an approach to take further action to reduce the risk of flooding.

Marsh Dykes – boroughs affected: Bexley, Greenwich.

90. There are a number of modified and natural rivers in the Thamesmead/Belvedere area which are unusual in that they are below the height of Thames flood defences and rely on a system of lakes, canals and pumping stations to manage their discharge to the tidal Thames.

91. TE2100 recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change). Furthermore it recommends careful consideration of new development given the particular risks of this low lying area and the difficulties in managing surface water following heavy rainfall events.

Fluvial River Thames- boroughs affected: Kingston, Richmond, *Spelthorne*, *Elmbridge*

92. The fluvial reaches of the Thames are prone to large flood events from its extensive upstream catchment. There are no built flood defences and this stretch of the river is particularly noted for its historic and cultural value. Given the large upstream catchment close co-operation is needed with flood risk management approaches further to the west.

93. The Environment Agency is developing the **River Thames Scheme**[28] (formerly Lower Thames Flood Risk Management Strategy). Between 2020 and 2025 the Environment Agency will build a new flood channel alongside the River Thames to reduce flood risk to 15,000 properties and 2,400 businesses in communities in Datchet, Wraysbury, Egham, Staines, Chertsey, Shepperton, Weybridge, Sunbury, Molesey, Thames Ditton, Kingston and Teddington. More than half of the funding required for the construction of the scheme has been identified, and the Environment Agency is working with partners to secure the additional funding needed.

Flood Risk Management Options

94. There needs to be continued work to ensure that the recommended policy approaches are implemented. The actual detail will require careful consideration of the rivers locally and their **floodplain characteristics**. In many cases setting development back from river edges will enable a range of flood risk management options to be used. This measure is referred to in the draft London Plan Policy SI12 and should enable the most sustainable, aesthetical and cost effective options to be selected.

[28] For details see www.gov.uk/riverthamesscheme

95. Boroughs and individual developments will need to consider the Sequential Test and the allocation of more vulnerable land uses to those areas at lowest risk.

96. Open spaces within development can be designed to accommodate flood waters. The Green Grid concept is a good example of identifying such opportunities. In some cases the flood risk is such that upstream flood storage may prove to be the most realistic option. Efforts to restore damaged river environments also present good opportunities to incorporate **natural flood management** techniques, which can improve flood risk management and bring other benefits, such as increased biodiversity. In October 2017 the Environment Agency published evidence on working with natural processes to reduce flood risk[29]. Such measures may need to be considered in conjunction with neighbouring local authorities.

97. Where a **residual flood risk** remains, flood risk assessments should consider what would happen to the development and its users/occupants if a flood were to occur and how the development would recover from the flooding.

The Likely Impact of Climate Change

98. Climate change predictions suggest that there will be an increased risk of flooding on tributary rivers due to more intense patterns of rainfall.

99. This gives added emphasis to the need to consider the above range of flood risk management options and the Environment Agency's recommendations from CFMPs. Furthermore methods of reducing surface water run off from urban development are important. This is the responsibility of the LLFAs and applies not only to development in or near to a floodplain or river but across London. For those rivers whose headwaters originate outside London, the GLA will seek to work with the relevant authorities.

Recommendation 2 – Fluvial Flood Risk
Regeneration and redevelopment on London's river corridors offer a crucial opportunity to reduce fluvial flood risk. Strategic Flood Risk Assessments (SFRAs) and planning policies should focus on making the most of this opportunity through appropriate location, layout and design of development as set out in the Thames Catchment Flood Management Plan (CFMP). In particular opportunities should be sought to set back development from the river edge; ensure that developments with residual flood risk are designed to be flood compatible and/or flood resilient; and maximise the use of open spaces to make space for flood water.

2.3 Surface Water Flood Risk

Nature of Risk

100. This section deals with rainfall that overwhelms the drainage system or is of such intensity that it flows over land. This kind of flooding can happen in **very localised areas** as a result of particularly intense storm cells and as such it is hard to predict. Some recent developments in radar technology and improved weather modelling suggest that it may be possible to predict these storm events more accurately in the future. However, even if these storms can be predicted, there is likely to be only scope

[29] For details see www.gov.uk/government/publications/working-with-natural-processes-to-reduce-flood-risk

for action for particularly sensitive sites/uses. Since the 2009 RFRA significant work has been undertaken to assess, map and understand surface water risks.

101. This is true nationally but in London has been given a particular focus through the **Drain London** project. Drain London is a partnership led by the Mayor, Environment Agency, Thames Water and London Councils. It has been successful in producing surface water flood risk mapping and Surface Water Management Plans (SWMPs) for every London Borough and has funded detailed studies into over 20 high flood risk areas. The project has been funded by Defra and broadened its remit more recently to investigate how more sustainable drainage can be implemented across London. This has led to the publication of the **London Sustainable Drainage Action Plan** (LSDAP) in Dec 2016[30]. There is also the London Drainage Engineers Group (LoDEG), a joint forum to help and facilitate collaboration between the 33 LLFAs within London and other strategic risk management authorities with regards to surface water flood risk and drainage issues.

102. Surface water flooding can be caused or exacerbated by blockages to the drainage network. New surface water drainage networks are normally designed to cope with storms of a 1 in 30 year intensity, however many existing systems may be constructed to different standards. It is to be expected that events above the design intensity will occur from time to time and will lead to surface water flooding.

Locations

103. Surface water flood risks occur in lower lying areas of all London boroughs. Given the complexity of the land form, topography and the drainage network it is **very difficult to predict precisely** where the risks will lie. Details such as the height of kerbs or level and construction of boundary walls can determine whether surface water flows one way or another. Therefore any London wide or borough wide mapping must only be taken as a general indication of risk areas.

104. However, in **central and inner London**, where the natural drainage systems have been largely removed and built over, surface water flood risk tends to occur in lots of small, localized areas representing slightly lower ground than the surrounding land. Basement properties and entrances to sub surface car parks, servicing yards etc. can be at particular risk of ingress of water. It should be noted that such basements often house important utilities such as electrical sub stations/meters, lift motors/control gear, back up power generators or computer servers. Often smaller natural drainage features such as tributary streams and ditches have been built over during the centuries of development, whilst the land may remain at a slightly lower level, thereby being likely to be subject to surface water flooding. Any blockages or failures of the drainage network will exacerbate such flooding and may even cause flooding in circumstances where the drainage system would otherwise have coped.

105. In the **rest of London** where the natural drainage system of rivers and streams remains, surface water flooding is often directed to the valleys of those streams which form the naturally lower land areas. Many of these urban rivers are immediately adjacent to built development or even underneath buildings and in such cases those

[30] For details see https://www.london.gov.uk/WHAT-WE-DO/environment/environment-publications/london-sustainable-drainage-action-plan

buildings may lie within risk areas. Away from those river corridors surface water will pond in lower lying areas.

106. **Buildings with large roof areas**, such as mainline rail terminals, hospitals, schools, retail warehouses are particularly prone to surface water risks under heavy rainfall situations. For such buildings it will be important to ensure that any new development proposals reduce those risks. Additionally, through the Drain London project, those risks have been examined and opportunities for retrofitting more sustainable drainage to reduce risks have been indentified.

107. It will often be unfeasible to address surface water risks at the specific location where the risk of flooding exists. Therefore it is important that steps are taken in the **surrounding contributory catchment areas** to manage surface water more sustainably. The implementation of draft London Plan Policy SI13 (Sustainable Drainage) and the LSDAP are therefore important across all of London and not just in identified risk areas.

Information available

108. This RFRA uses the Environment Agency's updated flood map for surface water. This is also integrated into the mapping tool on the Environment Agency website[31]. If an area has an identified significant surface water flood risk, then more detailed site specific analysis is recommended.

109. Lead Local Flood Authorities have a Duty under the F&WM Act 2010 to maintain a register of any significant flood events. There are still only relatively few well-documented records of surface water flooding. It often occurs and then dissipates quickly, usually within a few hours. Whilst historically this has made it difficult to make a reliable record of such an event, the prevalence of camera phones, social media and CCTV now makes it possible to **build up a more accurate picture** of such events and in future events are likely to be recorded on a much more consistent basis.

Flood Risk Management Options

110. There are a number of good practice examples of both site specific and more strategic scale sustainable drainage projects[32].

111. Where development proposals are on brownfield sites, there are real benefits to be gained by making a substantial reduction in the amount of surface water run-off generated through the **redevelopment** of the site. In cases where sites were used for predominantly industrial purposes the proportion of drained area is often close to 100% of the site. A residential development is likely to be in the range of 40-80% positively drained, leading to a reduction in surface water run-off. Adding in measures such as porous road and parking surfaces, green/blue roofs, storage ponds/tanks, swales and soakaways could reduce run-off to an estimated 20-50% of previous levels, and in some cases may be close to the natural (greenfield) run-off rate. This should be the aim of a sustainable approach to urban drainage.

[31] For details see https://flood-warning-information.service.gov.uk/long-term-flood-risk/map

[32] For details see www.london.gov.uk/what-we-do/environment/climate-change-weather-and-water/surface-water/sustainable-drainage-london

112. In some specific locations, for example where basements are at risk, there may be options to raise the threshold entrance to those basements. Additionally, as is often recommended for developments within the defended Flood Zone 3a, which meet the Exceptions Test, placing important infrastructure, such as electrical supplies, lift motors, computer servers, within a **flood proof room or enclosure** may be a viable option.

113. The LSDAP aims to encourage and incentivise the **retrofitting** of sustainable drainage measures into the existing urban environment. The key aim of the Action Plan is to provide guidance, advice and support to bring forward sustainable drainage measures as part of any maintenance/improvement projects planned for existing buildings/sites. The LSDAP will also consider how private individuals could be encouraged to adopt more sustainable rainwater management on their own properties.

114. It should also be remembered that for development close to tidal rivers, docks and potentially other water bodies, a **direct discharge** of clean rainwater to these may be the most sustainable option. Draft London Plan Policy SI13 promotes this option accompanied by suitable pollution prevention measures. However, in some cases direct discharge will not be appropriate, for example discharge into a small stream at the headwaters of a catchment, which may cause flooding.

115. There is also emerging evidence on rainwater management that relatively extensive green roofs, can have a significant effect in reducing surface water run-off, particularly for lower intensity rainfall events. More recently there have been developments which have used **blue roofs**. These can be green roofs engineered to retain water or attenuation tanks at roof level. By retaining water at roof level, opportunities for rainwater harvesting are increased, and there is also potential for the blue roof tank to provide irrigation to any green roof.

The Likely Impact of Climate Change

116. Current predictions anticipate that the intensity of storms is likely to increase. This will mean that both the likelihood and consequences of surface water flooding will increase as flood waters may be deeper given the higher volumes of rainwater. The application of the Drainage Hierarchy and the LSDAP should improve the ability of the urban area as a whole to cope with such storm events but individual locations will still be affected.

Recommendation 3 – Surface Water Flood Risk
Developments all across London should reduce surface water discharge in line with the Sustainable Drainage Hierarchy set out in Policy SI13 of the London Plan, and the actions in the London Sustainable Drainage Action Plan (LSDAP) should also taken.

2.4 Foul Sewer Flood Risk

Nature of Risk
117. Foul sewer flooding occurs where sewers become blocked or overloaded and properties connected to the sewer system are located at a level below the hydraulic level of the sewage flow. These are often basement flats or premises in low lying areas or where carriageway surcharging floods a property indirectly. Sewer flooding is clearly particularly unpleasant and distressing as its contents are highly contaminated. At present Thames Water estimates that there are over 10,000 properties which are vulnerable to sewer flooding across the whole of Thames Water's operational area.

118. Thames Water is planning to invest over £350million between 2015-2020 to combat sewer flooding at 2,000 properties. This includes their **Counters Creek** proposals for a large-scale sewer relief tunnel in the LB Hammersmith & Fulham and LB Kensington & Chelsea area. Some consultation has been undertaken, however, proposals are expected to be reviewed in early 2018. There will also be some potential for sustainable drainage measures, particularly within the combined sewer areas of London.

119. In most of central and inner London the surface water and sewerage networks are combined in '**Combined Sewers**'. During periods of heavy rain the combined sewage and rainwater is diverted to the River Thames via combined sewer overflows to prevent significant flooding of homes, businesses, streets and gardens.

120. The **Thames Tideway Tunnel**, currently under construction, will intercept overflows and transfer the flows for treatment at Beckton Sewage Treatment Works. It will prevent the discharge of millions of tonnes of untreated sewage and rainwater to the Thames.

Locations

121. The locations affected tend to be small discrete sub-catchments on the sewer network rather than any specific patterns or particular locations.

122. However, at a larger scale Thames Water has produced the Brent & Harrow Catchment Study[33] between 2015 and 2017. Jointly with LB Harrow, LB Brent, and the Environment Agency, they investigated the root causes of flooding and potential ways to reduce them across the catchment.

Information available

123. Detailed records of locations where sewer flooding has been recorded either within a property or within the grounds of a property are held by Thames Water. The locations are generally very sporadic and not suited to mapping on a London-wide basis.

Flood Risk Management Options

124. The nature of the problem dictates that the most effective solution is for Thames Water to carry out direct works to those parts of the sewer network linked to the affected property or group of properties. This is an expensive operation – averaging around £150,000 per property for the programme between 2015-2020.

125. Future developments should be catered for by ensuring that the appropriate on and off-site sewerage infrastructure is planned and delivered to serve proposed development (see also draft London Plan Policy SI5). In line with London Plan's Drainage Hierarchy (Policy SI13), it is also important that surface water is not discharged into the foul water system, thereby limiting its capacity.

[33] For details see https://corporate.thameswater.co.uk/About-us/Investing-in-our-network/Sewerage-catchment-studies/Brent-and-Harrow

The Likely Impact of Climate Change

126. In theory climate change should not make a substantial difference to this problem. However, in practice, as surface water drains are often wrongly connected to the foul system, the expected increase in intensity of storm events will increase the likelihood of sewer flooding. Similarly, within the combined sewer area of London, increases in rainfall will trigger additional combined sewer discharges to the Thames. In central London this problem will be largely overcome through the completion of the Thames Tideway Tunnel. In parallel, it will be important that new development follows the Drainage Hierarchy and that retrofitting is undertaken by implementing the LSDAP. This should ensure the continued effectiveness of the sewer system and prevent gradual increases in the number and scale of overflows to the new Thames Tideway Tunnel, in particular in the light of the likely incease in frequency of heavy rainfall events.

Recommendation 4 – Sewer Flood Risk
Thames Water should continue the programme of addressing foul sewer flooding, also working with other risk management authorities such as local authorities and the Environment Agency.

2.5 Groundwater Flood Risk

Nature of Risk

127. Groundwater flows out of the ground at the point where the water table meets the surface. This acts as the source of many rivers and is also a valuable source of drinking water. Heavy rainfall can **infiltrate the ground causing saturation**. Surplus water will then flow out to rivers or onto land potentially causing flooding. Groundwater tends to respond slowly to rainfall, so when groundwater flooding occurs it can persist for some time. Within London there have only been very few recorded groundwater flooding events, although it may be possible for groundwater to cause elevated base flows into some of the rivers entering London as a result of increased groundwater flows from the surrounding hills of the Chilterns or the North Downs. In February 2014 some South London boroughs were affected by groundwater flooding, with the Kenley Water Treatment Works and ca 50 properties affected in particular in Croydon and Bromley.

128. London had an issue over the past 20 or so years with **rising groundwater**. This has occurred because the majority of London, including much of its underground infrastructure such as tube lines and foundations for large buildings, was built at a time when the natural groundwater was suppressed due to large scale abstraction by manufacturing industry. With the steady reduction of industrial activity in London during the second half of the 20th century, groundwater levels began recovering to their natural levels thereby threatening to inundate the underground infrastructure or de-stabilize the ground surrounding the structures.

129. This problem was addressed by the **General Aquifer Research Development and Investigation Team** (GARDIT)[34]. Through increased abstraction of the groundwater, notably by Thames Water, groundwater levels are now relatively stable and the Environment Agency is maintaining a regular monitoring regime.

[34] Informal partnership originally led by Thames Water, London Underground and the Environment Agency oversee a programme of action to stabilise groundwater levels

Major Development Locations

130. There are no known mayor development locations where groundwater flooding has been a problem. The rising groundwater was mostly related to central and inner London, although this is now being managed.

131. The Drain London project undertook a London-wide assessment of groundwater flood risks. This combined several existing datasets to produce a **map of 'indicative Potential for Elevated Groundwater' (IPEG**), which provides a starting point for further investigations. Detailed site-specific assessments are important, particularly where deep excavation is involved or where there is an indication that the groundwater levels may be elevated. The areas highlighted in the IPEG map are generally quite sporadic across London. See Map 12 for an illustration of the IPEG.

Information available

132. The Environment Agency keeps detailed records of groundwater levels through a comprehensive monitoring regime. All boroughs with historic groundwater flooding records have incorporated them into their SFRAs. In addition, the IPEG maps can be used to highlight areas where there may be an increased potential for groundwater to rise sufficiently to cause flooding denoting where further, site-specific, assessment may be required as part of an FRA.

Flood Risk Management Options

133. The continued abstraction of water by Thames Water is important to manage groundwater levels in the foreseeable future. This is expected to continue.

The Likely Impact of Climate Change

134. Increased groundwater levels are normally the result of prolonged rainfall with a degree of delay built in as water percolates through the ground. It is not yet clear whether the increased amount of winter rainfall will increase this risk or, as the total amount of rainfall is expected to remain relatively unchanged (just fall in more concentrated periods), the effect upon groundwater patterns and flows may remain stable. This needs to be kept under review.

Recommendation 5 – Groundwater Flood Risk
The groundwater flood risk in identified locations (see IPEG map) should be considered in Strategic Flood Risk Assessments (SFRAs) and Flood Risk Assessments (FRAs).

2.6 Reservoir Flood Risk

Nature of Risk

135. Reservoir flooding is extremely unlikely to happen. There has been no loss of life in the UK from reservoir flooding since 1925. Specific reservoirs must be inspected and supervised by reservoir panel engineers. As the enforcement authority for the Reservoirs Act 1975 in England, the Environment Agency ensures that reservoirs are inspected regularly and essential safety work is carried out. However, in the unlikely event that a reservoir dam failed, a large volume of water would escape at once and flooding could happen with little or no warning. The resulting high consequence of flooding means

that, although flooding from reservoirs is considered to be of very low likelihood, the risk should be considered in SFRAs and FRAs.

Major Development Locations

136. The reservoirs in the Lower Lee Valley are the largest reservoir area within the GLA boundaries. They are well maintained and monitored. In the unlikely event of a reservoir flood, the Lower Lee Valley downstream from the reservoirs could be significantly affected. Similarly the large reservoirs to the west of London are well maintained, but in the unlikely event of a failure, parts of west London could be affected. There are a number of other smaller reservoirs, whose areas of potential inundation are shown on Environment Agency mapping (see below).

Information available

137. Reservoir flood maps, which are included in the Envionrment Agency mapping tool on their website[35], were introduced after the 2009 RFRA. An extract covering London is included as illustration as Map 13. Reservoir maps display information for large reservoirs holding over 25,000 cubic meters of water. They show the largest area that might be flooded, if a reservoir were to fail and release the water it holds. They do not display information about how likely any area is to be flooded or about the depth or speed of the flood waters.

Flood Risk Management Options

138. The Water Act 2003 amended the Reservoirs Act 1975 and introduced a requirement for reservoir flood plans. Since August 2013 requirements are based on risk and not on size[36]. The Environment Agency has therefore designated specific reservoirs as High Risk. Some of these designations are under review.

139. The Reservoirs Act requires that reservoir owners undertake all necessary steps to prevent breaches from occurring following regular inspection and reporting. The likelihood of breaching is very low, and therefore , when considering flood risk to new development it is unlikely that any particular mitigation measures will be required, unless a high vulnerability development was proposed immediately downstream of a high risk reservoir. There may also be implications for emergency planning and it may be necessary to incorporate the following aspects of the relevant **reservoir safety plan**, which represents an element of the reservoir flood plan and includes the three aspects below, into emergency plans for new developments:

- a reservoir flood map by the Environment Agency which identifies the extent and severity of flooding which could result from an uncontrolled release of water;
- an on-site reservoir emergency plan by the reservoir owner setting out what would be done in an emergency to try to contain and limit the effects of the incident. It will include a plan for communicating with external organisations, mainly the emergency services but also for example transport network operation centres;
- an off-site reservoir emergency plan by the Local Resilience Forum (LRF) setting out what the emergency services will do to warn and protect people and property downstream in the event of an incident which could lead to dam failure.

[35] For details see https://flood-warning-information.service.gov.uk/long-term-flood-risk/map
[36] The Act applies to reservoirs over 25,000 m3 in England.

The Likely Impact of Climate Change

144 For offline reservoirs (ie reservoirs where water has to be pumped or diverted into the reservoir) it is unlikely that climate change will have a significant impact on reservoir floodrisk. For online reservoirs (ie reservoirs which have watercourses flowing into and out of them) there could be an increased risk of flooding due to higher inflows. In either case this will be monitored through the above mentioned strict management arrangements, including other possible risk factors such as drought or waterlogging reducing the stability of reservoir embankments.

Recommendation 6 – Reservoir Flood Risk
The reservoir flood risk in identified locations (see reservoir flood map) should be considered in Strategic Flood Risk Assessments (SFRAs) and Flood Risk Assessments (FRAs).

Chapter 3– Spatial Implications of Flood Risk

3.1 Introduction

140. Chapter 1 dealt with the strategic overview of flood risk in London with particular reference to the London Plan. Chapter 2 dealt with a more detailed analysis of the risk from the six types of flooding that could affect London. Chapter 3 now examines flood risk in relation to strategic growth locations (Opportunity Areas and Town Centres) and infrastructure assets. Appendix 3 provides the related maps and detailed statistics. Further information in terms of relevant definitions and assumptions are provided directly on the maps themselves.

London Boroughs – Strategic Flood Risk Appraisals (SFRAs)

141. Most London boroughs have some extent of identified flood risk; see Map 1. For some this is limited to small areas along tributary streams, for others it includes large areas with potential for tidal flooding across a large proportion of the borough.

142. All boroughs have SFRAs in place, but these will need to be **kept up to date** and reviewed approximately every 3-5 years or as and when significant new data becomes available. Many London boroughs are currently updating their SFRAs. For specific strategic purposes joint SFRAs have been produced, including one for East London and one for North London to support the North London Waste Plan.

143. It is important for SFRAs to identify areas where there are **particular flood risks**. For example, some low lying areas of land will be susceptible to ponding of water, in other areas there may be particular risks of a breach of flood defences or rapid inundation of flood waters with high velocities. This type of analysis will assist in determining locations where development may have to be constrained or altered to avoid particularly high risks.

144. The SFRAs represent a baseline study of flood risk for each borough and have generated detailed descriptions of prevailing flood risk. **When the SFRAs are updated**, they should consider further;

- Where appropriate, taking forward key recommendations into flood risk management policies within the Local Plans.
- Using the characterisation of risk to identify areas where redevelopment could be an opportunity to reduce flood risk. Where redevelopment is likely and capable of contributing to a reduction in flood risk (reducing probability and/or consequence), this could be achieved for example through relocating buildings, improving layout and design (designing in resistance), removing certain vulnerable land uses or providing flood compatible open spaces.

145. These issues may require **design considerations** at the masterplan or community scale and a SFRA could identify where this type of planning is required. Some SFRAs have started to present this analysis through identification of character areas, others have started to link spatial planning policy to enhancement of emergency planning capability.

146. Complementing this planning specific tool, the London boroughs also have to produce – in their role as LLFAs - **Local Flood Risk Management Strategies** based on the F&WM Act 2010 requirements with measures to address local flood risk in their areas. All boroughs have at least draft strategies in place. They also have to maintain a register of Flood Risk Management Assets and must investigate reports of flooding.

3.2 Specific Development Areas

Opportunity Areas

152. The new draft London Plan continues to designate Opportunity Areas as major development locations. These are the places where London will accommodate a significant share of its anticipated growth and where large scale development is expected to take place over the Plan period. Each of these will involve up to several thousand new dwellings and/or employment space for up to several thousand people and frequently a mix of many different land uses to promote sustainable development.

153. All 50 Opportunity Areas, including ten emerging ones[37], have some form of identified flood risk. Map 2 illustrates that Earls Court, the Isle of Dogs and Kensal Canalside have the **highest proportion of high flood risk areas** (17, 16 and 15 per cent respectively). The Royal Docks, London Riverside, Kingston Town Centre, Victoria and the Upper Lea Valley follow with ten or more percent. On average seven per cent of Opportunity Areas are at high risk of flooding. All individual Opportunity Area risk figures are provided alongside Map 2. The assessment of the Opportunity Areas, as key locations for future growth, does not only consider 1 in 30 and 1 in 100 year events (high and medium risk), but also 1 in 1000 year events (low risk). This precautious approach was agreed with the Environment Agency as an appropriate reflection of the revised allowances.

154. **Integrated Water Management Strategies** should be considered for Opportunity Areas, where an integrated approach to the management of risk and water-related infrastructure is required.

155. A brief overview of current flood risk characteristics and **potential mitigation** measures for all of them is included in Table 1. For better distinction between river/tidal and surface water flood risk issue, the latter element is included in red, and the emerging new Opportunity Areas are on a blue background. The table represents a broad flood risk framework for more detailed investigations at the level of the individual location. In terms of surface water flood risk these major development locations offer opportunities to divert surface water away from the existing drainage network into more sustainable rainwater use or disposal techniques. This is especially important in areas served by the combined sewer network, as the benefits will also reduce the costs of operating the sewerage system. Furthermore, if planned across large scale developments such measures can reduce development costs compared with the provision of conventional drainage infrastructure.

156. The presence of an element of flood risk is something that needs to be understood, planned and managed. Appropriate development can still come forward and may actually result in a reduction of flood risk both on site and for surrounding

[37] Hays, Great West Corridor, Wood Green, New Southgate, Romford, Poplar Riverside, Sutton, Kingston, Wimbledon, and Clapham Junction

areas. A **further consideration** in these important locations is to ensure that critical infrastructure is either located away from flood risk areas or has a high standard of protection.

Table 1: Flood Risk in Opportunity Areas

	Current flood risk characteristics	Potential flood risk mitigation measures
Bexley Riverside	Mainly within Flood Zone 3, downstream of the Thames Barrier, with a high level of protection from storm surges by raised river walls. Contains several shipping-related industries requiring operational access to the river. Also contains parts of the Darent floodplain with a high level of protection by tidal defences. There are some surface water flood risk areas particularly where there is a dominance of large impermeable areas. Some areas rely on pumped drainage.	Located in the Thamesmead and Dartford and Erith TE2100 policy units. Raising river walls and embankments required by 2040 to keep up with climate change and keep flood risk at current levels. Open spaces to be retained for potential flood storage and work to flood defences in future. Need to consider future of Darent Industrial Estate and potential use of Crayford Marshes for tidal storage. Outputs from the River Cray flood risk management asset study should be considered. An Integrated Water Management Strategy has been produced. Measures to reduce surface water run-off will be important. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve Greenfield run-off rates and reduce the current risks. Development close to the Thames can discharge directly to the river.
Bromley	Partially within Flood Zones 2 and 3 with fluvial flood risks along River Ravensbourne to the west of town centre and a tributary watercourse running close to Bromley South Station. Surface water risks broadly follows fluvial floodplains with some areas at risk of deep surface water flooding in extreme events.	Investigate opportunities to reduce flood risk from River Ravensbourne. Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. Given the identified flood risk the control of surface water is particularly important for the development of the area. It is also important to consider the role of multipurpose open spaces and additional drainage attenuation from large roof/hardstanding areas.

	Current flood risk characteristics	Potential flood risk mitigation measures
Canada Water	Wholly within Flood Zone 3 and with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Relatively minor surface water flood risks focused on London Overground lines around Surrey Quays station and Rotherhithe Tunnel approach road.	Located in Wandsworth to Deptford TE2100 policy unit. Raising river walls required by 2065 to keep up with climate change and reduce flood risk further. Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. Existing water spaces and nearby green infrastructure will provide good opportunities for sustainable drainage.
Charlton Riverside	Mainly within Flood Zone 3 and straddling the Thames Barrier, with a high level of protection from storm surges by raised river walls but with land lying significantly below high tide levels. There are notable areas of surface water flood risk around Horn Lane, Westmoor – Eastmoor Streets and at the low point on Bugsbys Way under the freight rail bridge.	Located in the Greenwich TE2100 policy unit. Raising river walls and embankments required by 2065 to keep up with climate change and reduce flood risk further. Open spaces to be retained for potential flood storage and work to flood defences in future. An Integrated Water Management Strategy has been produced. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve Greenfield run-off rates and reduce the current risks. Development close to the Thames can discharge directly to the river.
City Fringe / Tech City	Mainly within Flood Zone 1, the southern extremes have a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Relatively minor surface water flood risks mainly focused on the public highway network and the sub surface National Rail lines north of Liverpool St Station.	Located in the London City TE2100 policy unit. Raising river walls required by 2065 to keep up with climate change and reduce flood risk further. Open spaces to be retained for potential flood storage and work to flood defences required in future. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks.

	Current flood risk characteristics	Potential flood risk mitigation measures
Clapham junction	Mainly within Flood Zone 3 but with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Some areas of significant surface water flood risk, notably to the north of Clapham Jcn station.	Located in Wandsworth to Deptford TE2100 policy unit. Raising river walls required by 2065 to keep up with climate change and reduce flood risk further; also setting development back from river's edge. Climate change is expected to increase the residual risks posed by breaches in the tidal defences and it is important that developments take account of this residual risk when considering the safety of proposed developments. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. Given the extent of surface water risks, there may be merit in delivering a strategic drainage solution.
Colindale / Burnt Oak	Part of the area is within Flood Zones 2 and 3 and contains Silk Stream, a River Brent tributary where localised flooding has been recorded. Some surface water flood risk areas notably along tributary river corridors, especially in the vicinity of Burnt Oak LU Station.	Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks.
Cricklewood / Brent Cross	A small proportion of area is within Flood Zones 2 and 3 with some local flood history on the River Brent. There are some surface water flood risk areas with recently recorded flooding history particularly along the River Brent corridor, the A406 where it passes under the A41, the A41 south of the A406, Cricklewood Lane near Crickelwood Station and around Prayle Grove.	Set development back from river's edge to enable a range of flood risk management options. Investigate opportunities to reduce flood risk from River Brent including opportunities to restore canalised/culverted watercourses. New development is a good opportunity to introduce more sustainable rainwater management and there should be good scope for sustainable drainage options to achieve greenfield run-off rates and reduce the current risks.
Croydon	Part of the area is within Flood Zones 2 and 3 of the River Wandle. Extensive areas of surface water flood risk along the route of the largely buried River Wandle. Drain London/LB Croydon have funded an initial study into this risk area. Groundwater flood risk is also an issue.	Investigate opportunities to reduce flood risk for the River Wandle/Caterham Bourne. Measures to reduce surface water run-off will be important. New development is a good opportunity to introduce more sustainable rainwater management and there should be good scope for sustainable drainage options to achieve substantial reduction in run-off rates and reduce the current risks. The Caterham Bourne Flood Alleviation Scheme is being considered also to address groundwater flood risk.

	Current flood risk characteristics	Potential flood risk mitigation measures
Deptford Creek / Greenwich Riverside	Mainly within Flood Zone 3, with a high level of protection from daily tidal flooding and fluvial flooding from the River Ravensbourne by river walls and from tidal surges by the Thames Barrier. Localised areas of surface water flood risk with some particular risk areas along the national rail lines through Greenwich Town Centre.	Located in the Greenwich and Wandsworth to Deptford TE2100 policy units. Raising river walls required by 2065 to keep up with climate change and reduce flood risk further. Investigate opportunities to reduce flood risk from River Ravensbourne. Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. Development close to the Thames can discharge directly to the River thames/Deptford Creek.
Earls Court and West Kensington	Partially within Flood Zone 3 and with a high level of protection from storm surges by raised river walls. Documented surface water/sewer flood risk areas and known capacity problems in the Counters Creek catchment affecting thousands of properties. London Overground and Underground rail lines at risk and areas close to large footprint buildings. It is notable that many older properties in the area have basements which will be at a higher risk of overflow from the highway network.	Located in the Hammersmith TE2100 policy unit. Need to consider the role of multipurpose open spaces for flood risk management and management of surface water. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks, as has been achieved at Westfield with substantial rainwater storage. Thames Water is developing the Counters Creek sewer flood relief tunnel project within this area.
Elephant and Castle	Wholly within Flood Zone 3 and with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Relatively minor surface water flood risk present focus on the public highway network.	Located in Wandsworth to Deptford TE2100 policy unit. Raising river walls required by 2065 to keep up with climate change and reduce flood risk further. Set development back from rivers edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks.
Euston	Within Flood Zone 1 with no floodplain identified. Relatively minor surface water flood risks, mainly focused on the public highway network with the exception of more significant risks to the sub surface National Rail lines north of Euston Station and Euston Rd underpass.	HS2 and Euston development need to fully consider flood risks in the area. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks.

	Current flood risk characteristics	Potential flood risk mitigation measures
Great West Corridor/Golden Mile	Mainly Flood Zone 1 although eastern parts include Flood Zone 3 from tidal Thames and River Brent floodplains. Some areas have significant surface water flood risks, mainly to the south of Great West Road.	Set development back from river's edge to enable a range of flood risk management options and deliver TE2100 recommendations where appropriate. Investigate opportunities to reduce flood risk from River Brent. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. New development in areas of significant surface water flood risk may also need specific mitigation measures.
Greenwich Peninsula	Wholly within Flood Zone 3 and with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Contains several shipping related industries requiring operational access to river. Some surface water flood risk areas notably along existing highways.	Located in Greenwich TE2100 policy unit. Raising river walls required by 2065 to keep up with climate change and reduce flood risk further. Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks, Development close to the Thames can discharge directly to the river and much of the rest of the peninsula can connect into a surface water drainage system that discharges to the Thames.
Haringey Heartlands / Wood Green	Flood Zone 1 although includes upper reaches of Moselle brook in culvert. Relatively minor surface water flood risks, mainly focused on the public highway network with higher risk areas to the west of the National Rail lines.	Set development back from culverts. Consider opportunities to reduce flood risk/open the culvert for the Moselle Brook. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks and in particular the discharge to the Moselle Brook.
Harrow and Wealdstone	Some areas are located in Flood Zone 3 of the Wealdstone Brook floodplain. The Brook flows through the site in culvert. Some surface water flood risk areas particularly to the highway network including low lying parts of the High St, Masons Ave and around Kenmore Ave. The combination of surface water, sewer and fluvial flooding are of concern.	Set development back from culverts and seek opportunities to open up culverted sections of the river. Look at opportunities to reduce flood risk for the Wealdstone Brook. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a greenfield run-off rates and reduce the current risks in the area and downstream, where there are particularly acute risks.

	Current flood risk characteristics	Potential flood risk mitigation measures
Hayes	Mainly Flood Zone 1. Some areas have significant surface water flood risks, mainly around Hayes town Centre.	New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. New development in areas of significant surface water flood risk may also need specific mitigation measures.
Heathrow	Relatively small proportion of the area within Flood Zones 2 and 3. Relatively minor surface water flood risks, although potentially risks to sub surface roads/rail. Heathrow benefits from the presence of surface water balancing ponds.	Set development back from river's edge to enable a range of flood risk management options. Need to consider the role of multipurpose open spaces for flood risk management and management of surface water. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve greenfield run-off rates and reduce the current risks.
Ilford	Mainly Flood Zone 1 but a very small proportion of area within Flood Zone 3 of the River Roding. Relatively minor surface water flood risks, mainly focused on the public highway network with the exception of the Cranbrook corridor along parts of Northbrook Road and parts of the National Rail lines east of Ilford Station where risks are more significant.	Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks.
Isle of Dogs	Mainly within Flood Zone 3 but with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Some localised surface water flood risks, mainly focused on the public highway network.	Raising river walls by 2065 to keep up with climate change and reduce flood risk further. Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. Development close to the Thames and docks can discharge directly to the river.
Kensal Canalside	Flood Zone 1. Grand Union Canal runs alongside the site. Some localised surface water flood risks, and the area contributes to the already overloaded Counters Creek combined sewer catchment.	Set development back from canal edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve greenfield run-off rates and reduce the current risks and discharge rates into the combined sewer system. Development close to the Grand Union Canal may be able to discharge directly to the canal.

	Current flood risk characteristics	Potential flood risk mitigation measures
Kings Cross – St Pancras	Flood Zone 1. Grand Union Canal runs through the site. Relatively minor surface water flood risk, mainly focused on the public highway network and sub surface National Rail lines.	Set development back from canal edge. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks, in particular around mainline station.
Kingston – New Malden	Mainly Flood Zone 1 with some significant areas of Flood Zones 2 and 3, notably around Kingston Town centre and along the Hogsmill River. Some areas have significant surface water flood risks, mainly to the north of Kingston Town centre and north of new Malden.	Set development back from river's edge to enable a range of flood risk management options. Environment Agency investigating a Lower Thames Flood Defence scheme, new development should allow for any appropriate interventions. Investigate opportunities to reduce flood risk from Hogsmill River. New development in areas of significant surface water flood risk may need specific mitigation measures. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. New development in areas of significant surface water flood risk may also need specific mitigation measures.
Lewisham / Catford / New Cross	Significant areas located within Flood Zones 2 and 3 within the floodplains of the Ravensbourne, Quaggy and Thames rivers. Catford and Lewisham have the River Ravensbourne and its tributaries running through them with locally recorded flooding. There is a high level of protection from daily tidal flooding by river walls and from tidal surges by the Thames Barrier. A fluvial flood risk defence scheme is under consideration by the Environment Agency. Extensive areas of surface water flood risk along the tributary rivers through Catford and Lewisham Town Centres, some of these areas are at risk of deep surface water flooding in extreme events.	Part of the Opportunity Area is located in the Wandsworth to Deptford and Greenwich TE2100 policy units. Defence raising required on the Thames frontage by 2065 to keep up with climate change and reduce flood risk further. Need to consider the role of multipurpose open spaces within the wider development areas. Development to be set back from tributary river edges to enable a range of flood risk management measures. Safeguarding land potentially required for future flood risk management measures on fluvial watercourses. Comply with the recommendations of the River Ravensbourne river corridor improvement plan and Environment Agency requirements for improving flood risk management. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. Given the spread and depth of flood risk the control of surface water within this area and its contributing catchment is particularly important.

	Current flood risk characteristics	Potential flood risk mitigation measures
London Bridge, Borough & Bankside	Wholly within Flood Zone 3 and with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Relatively minor surface water flood risks, mainly focused on the public highway network.	Located in Wandsworth to Deptford TE2100 policy unit. Raising river walls required by 2065 to keep up with climate change and reduce flood risk further. Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. Development close to the Thames can discharge directly to the river.
London Riverside	Mainly within Flood Zone 3, downstream of the Thames Barrier and with a high level of protection from daily flooding and storm surges by raised river walls. Contains many shipping-related industries requiring operational access to river. Tributary rivers of Rainham Creek, Rom/Beam, Gores Brook and River Roding. Relatively few incidences of flooding in the past. Relatively minor surface water flood risks, mainly focused on the public highway network and around existing water features.	Located in Barking and Dagenham and Rainham Marshes TE2100 policy units. Raising river walls and embankments required by 2040 to keep up with climate change and keep flood risk at current levels. Open spaces to be retained for potential flood storage. Set development back from river's edge to enable a range of flood risk management options. The area may have a role for strategic flood storage – notably when tributaries become tide locked. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve greenfield run-off rates and reduce current risks. Development close to the Thames can discharge directly to the river.
New Southgate	Mainly Flood Zone 1 with some localised areas of Flood Zones 2 and 3, along Strawberry Vale Brook. Some areas have significant surface water flood risks, notably affecting the North Circular Road.	New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks of both surface and fluvial flood risk. Potential to utilise large areas of open space for strategic surface water/flood storage.
Old Kent Road	Mainly within Flood Zone 3 and with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Mostly relatively minor surface water flood risks but more extensive risk areas in the eastern part of the area close to Ilderton Rd and just outside the Opportunity Area to the south of Old Kent Rd.	Located in Wandsworth to Deptford TE2100 policy unit. Raising river walls required by 2065 to keep up with climate change and reduce flood risk further. Set development back from rivers edge to enable a range of flood risk management options. An Integrated Water Management Strategy has been produced. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks both within and just outside the eastern edge of the Opportunity Area.

	Current flood risk characteristics	Potential flood risk mitigation measures
Old Oak Common	Wholly within Flood Zone 1, Grand Union Canal runs through the site. Surface water risks generally localised and small scale, although some rail cuttings and road underpasses identified as at risk. The area drains to the already overloaded Counters Creek Catchment.	Set development back from canal edge. An Integrated Water Management Strategy has been produced. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks and discharge rates into the local combined sewer network.
Paddington	Wholly within Flood Zone 1. Grand Union Canal/Paddington Basin runs through the site. Relatively minor surface water flood risks. It is notable that many older properties in the area have basements which will be at a higher risk of overflow from the highway network.	Set back development from canal edge. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks, in particular around the main line station. Development close to the Paddington Basin should be able to discharge rainwater to the basin.
Park Royal	Part of the area lies along the River Brent to the west of North Circular and is within Flood Zones 2 and 3. Grand Union Canal runs through the site. Some areas of localised surface water flood risks focused in areas close to large footprint buildings, A406 underpasses and lower stretches of the rail network.	Investigate opportunities to reduce flood risk from River Brent. Set development back from river and canal edges to enable a range of flood risk management options. An Integrated Water Management Strategy has been produced. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve greenfield run-off rates and reduce current risks. Development close to the Grand Union Canal may be able to discharge directly to the canal. It is also important to consider the role of multipurpose open spaces and additional drainage attenuation from large roof/hardstanding areas.
Poplar Riverside	Mainly Flood Zone 3 from tidal Thames and River Lee floodplains but with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Generally low to medium risks of surface water flooding.	Raising river walls by 2065 to keep up with climate change and reduce flood risk further. Set development back from river's edge to enable a range of flood risk management options. Investigate opportunities to reduce flood risk from River Lee. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. Opportunities to divert rainwater directly to the River Lee and River Thames.

	Current flood risk characteristics	Potential flood risk mitigation measures
Romford	Mainly Flood Zone 1 with some localised areas of Flood Zones 2 and 3. Some areas have significant surface water flood risks, notably around Romford Town centre.	New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. New development in areas of significant surface water flood risk may also need specific mitigation measures including investigation of opportunities to de-culvert and naturalise the River Rom and Black Brook.
Royal Docks and Beckton Waterfront	Almost entirely within Flood Zone 3, the area straddles the Thames Barrier so has a high level of protection from storm surges by the Barrier and by raised walls downstream. Various watercourses flow through the site. Relatively minor surface water flood risks, mainly focused on the public highway network including parts of North Woolwich Road and lower parts of Royal Albert Way and lowers DLR lines along Royal Albert Way.	Located in Royal Docks TE2100 policy unit. Raising river walls and embankments required by 2040. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve greenfield run-off rates and reduce current risks. Development close to the Thames and docks can discharge directly to the river.
Southall	Flood Zone 1 but close to floodplain of Yeading Brook. Grand Union Canal runs alongside the site. Some localised surface water flood risks, mainly focused on the public highway network.	Need to ensure that development does not increase flood risk. Set back development from canal edge. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve greenfield run-off rates and reduce current risks. Development close to the Grand Union Canal may be able to discharge directly to the canal.
Sutton	Flood Zone 1 Some areas have significant surface water flood risks, mainly to the south of Sutton Town centre.	New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. New development in areas of significant surface water flood risk may also need specific mitigation measures.

	Current flood risk characteristics	Potential flood risk mitigation measures
Thamesmead and Abbey Wood	Almost entirely within Flood Zone 3 within the tidal Thames floodplain with large areas significantly below high tide level. Parts of the area are dependent on pumping stations and storage reservoirs for continuous flood risk management. Various watercourses flow through the site. There are some surface water flood risk areas particularly where the National Rail line embankment acts as an informal flood barrier. There are surface water features within Thamesmead and some areas rely on pumped drainage.	Located in Thamesmead TE2100 policy unit. Raising river walls and embankments required by 2040 to keep up with climate change and keep flood risk at current levels. New development needs careful consideration, particularly of residual risks and emergency measures. Set development back from river's edge to enable a range of flood risk management options. An Integrated Water Management Strategy has been produced. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. Development close to the Thames can discharge directly to the river.
Tottenham Court Road	Flood Zone 1. Relatively minor surface water flood risks. It is notable that many older properties in the area have basements which will be at a higher risk of overflow from the highway network.	New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks.
Upper Lee Valley	Includes extensive areas of Lee Valley floodplain and contains areas of Flood Zone 2 and 3. River Lee and tributaries flow through the area. Some notable surface water risk areas around Tottenham Hale and SW of Northumberland Park, Hall Lane and industrial estates close to the A406 and some low lying parts of the River Lee floodplain.	Investigate opportunities to reduce flood risk from River Lee. Set development back from river's edge to enable a range of flood risk management options. Need to consider the role of multipurpose open spaces within the wider development area. Should be considered in association with measures across London's boundaries in Herts and Essex. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. In areas close to the Lee Valley greenfield run-off rates should be achievable with options for discharges to the River Lee.

	Current flood risk characteristics	Potential flood risk mitigation measures
Vauxhall / Nine Elms / Battersea	Mainly Flood Zone 3 and with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Contains several shipping related industries requiring operational access to river. Relatively minor surface water flood risks, mainly focused on the public highway network with the exception of more significant risks on streets to the north west of Wandsworth Road. The access road into New Covent Garden under the railway lines is shown at particular risk and should be investigated.	Located in Wandsworth to Deptford TE2100 policy unit. Raising river walls required by 2065 to keep up with climate change and reduce flood risk further. Set development back from river's edge. Climate change is expected to increase the residual risks posed by breaches in the tidal defences and it is important that developments take account of this residual risk when considering the safety of proposed developments. An Integrated Water Management Strategy has been produced. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve greenfield run-off rates and reduce the current risks. Development close to the Thames can discharge directly to the river and Thames Water is investing in new surface water infrastructure to enable more clean water to discharge to the river.
Victoria	Partially within Flood Zone 3 and with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Some significant surface water flood risk, mainly focused on the public highway network and the National Rail lines into Victoria Station. It is also notable that many older properties in the area have basements which will be at a higher risk of overflow from the highway network.	Located in London City TE2100 policy unit. Raising river walls required by 2065 on river frontage section to keep up with climate change and reduce flood risk further. Set development back from rivers edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks, in particular around mainline station.
Waterloo	Wholly within Flood Zone 3 and with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Relatively minor surface water flood risks, mainly focused on the public highway network with a concentration around Waterloo Station.	Located in Wandsworth to Deptford TE2100 policy unit. Raising river walls required by 2065 to keep up with climate change and reduce flood risk further. Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks, in particular around mainline station. Development close to the Thames can discharge directly to the river.

	Current flood risk characteristics	Potential flood risk mitigation measures
Wembley	Some areas are within Flood Zones 2 and 3 of the Wealstone Brook/River Brent, which flow through the area. Relatively minor surface water flood risks focused on the Wealdstone Brook corridor and areas close to large footprint buildings.	Investigate opportunities to reduce flood risk from River Brent. Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve greenfield run-off rates and reduce current risks. It is also important to consider the role of multipurpose open spaces and additional drainage attenuation from large roof/hardstanding areas.
White City	Small part of the area is within Flood Zone 3 and with a high level of protection from daily flooding by river walls and from tidal surges by the Thames Barrier. Some significant surface water risk areas in/close to the area. The area drains to the already overloaded Counters Creek Catchment.	Located partially within Hammersmith TE2100 policy unit. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks and reduce discharge rates into the local combined sewer system, as has been achieved at Westfield with substantial rainwater storage. It is also important to consider the role of multipurpose open spaces and additional drainage attenuation from large roof/hardstanding areas.
Wimbledon	Mainly Flood Zone 1 with some significant areas of Flood Zones 2 and 3, along the River Wandle corridor. Some areas have significant surface water flood risks, mainly to the south west of Wimbledon Chase.	Investigate opportunities to reduce flood risk from River Wandle. Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks. New development in areas of significant surface water flood risk may also need specific mitigation measures.
Woolwich	Mainly within Flood Zone 3, downstream of the Thames Barrier and with a high level of protection from storm surges by raised river walls but with land lying significantly below high tide levels. Some parts of Woolwich Town Centre, notably the national rail lines are at risk of surface water flooding with flows running off the ridgeline to the south.	Located in Thamesmead TE2100 policy unit. Raising river walls and embankments required by 2040 to keep up with climate change and keep flood risk at current levels. Open spaces to be retained for potential flood storage. Set development back from river's edge to enable a range of flood risk management options. New development is a good opportunity to introduce more sustainable rainwater management and should readily be able to achieve a substantial reduction on current run-off rates and reduce the current risks.

Town Centres and the Central Activities Zone

157. **Intensification** of development at Town Centre locations is generally sustainable, given the high levels of public transport accessibility and concentration of facilities. New development will still need to be accompanied by a Flood Risk Assessment where required as set out in the NPPF.

158. Given that development in town centres tends to be high density, there are likely to be high run-off rates and limited scope for floodwater or rainwater attenuation in the immediate vicinity. In addition, many new developments will come forward in a piecemeal manner. Therefore, surface water management in constrained town centre sites needs to be considered particularly early in the design process so it can be satisfactorily accommodated and managed.

159. Map 3 illustrates that Kingston and Woolwich have the highest proportion of their **town centres in areas of high flood risk** (34 and 27 per cent respectively). Hammersmith (23 per cent), Canary Wharf (22 per cent) and Lewisham (19 per cent) follow. On average 13 per cent of Metropolitan and 9 per cent of Major town centres are at high risk of flooding. All individual town centre risk figures are provided alongside Map 3 and a brief overview of flood risk issues for all of them is included in Table 2.

160. The **Central Activities Zone** (CAZ), which includes both the West End and Knightsbridge International Town Centres as well as a number of Opportunity Areas and Areas of Intensification, is at risk of tidal flooding from the Thames, which flows through the CAZ. Flood risk to the south of the Thames and in particular in the Pimlico/Victoria area is quite extensive. However, the area is defended to a very high standard by a combination of the Thames Barrier and the Thames tidal flood defences. Particular attention should nevertheless be paid to the layout and design of development close to the River itself in order to allow for the appropriate maintenance and potential upgrade of the flood walls. Setting development back from the existing walls will generally be desirable in order to enable a range of flood risk management options. Consideration should also be given to the residual risk should the defences fail or be breached. This includes locating significant infrastructure and more vulnerable types of development in areas at lowest risk or implementing flood resilience measures. In addition developments with basements should consider the safety, continuity of services and recovery from a flood, should one occur.

161. Surface water flood risks are relatively minor for the majority of the CAZ but particular attention should be paid to flood risk management for any specific low lying areas and to buildings with basements. Sustainable Drainage techniques should be delivered wherever is reasonably practical and there is increasing evidence of such techniques being implemented in high density CAZ locations to achieve significant reductions in rainwater discharge rates. Green roofs and rainwater harvesting systems can be economically viable for commercial and even residential development within the CAZ. Locations close to the Thames may be able to discharge clean rainwater direct to the Thames without the need for any other attenuation measures.

Table 2: Flood Risk in Town Centres

Metropolitan centres	
	Flood Risk Issues
Bromley	Small proportion within the River Ravensbourne floodplain and significant surface water risk areas co-inciding with the Ravensbourne floodplain and flow path from the east passing under Bromley South station
Croydon	Partially within the River Wandle floodplain and close to culverted sections of the river and significant surface water risk areas co-inciding with the former course of the River Wandle
Ealing	No identified fluvial flood risk issues but surface water flood risk areas have been identified along rail lines
Harrow	No identified fluvial flood risk issues but surface water flood risk areas have been identified along rail lines and the Town Centre is upstream of an area that suffers significant flood risk
Hounslow	No identified fluvial flood risk issues but some surface water flood risk areas have been identified close to LU rail lines
Ilford	Small proportion within the River Roding floodplain and some relatively minor surface water risks affecting rail lines to the east of the town centre and Northbrook Road to the north
Kingston	Substantially within the floodplains of the River Thames and the Hogsmill River and some localised areas of surface water flood risk
Romford	Partially within the River Rom floodplain, river flows through the Town Centre in a culvert and significant surface water risks following the River Rom and River Ravensbourne corridors through the Town Centre
Shepherd Bush	Small proportion within the River Thames floodplain which is well defended. Some localised areas of surface water risk identified, notably along rail lines and in the vicinity of Tadmor St.
Stratford	Partially within the River Lee floodplain, and some localised surface water risk areas mainly affecting below ground level rail corridors
Sutton	No identified fluvial flood risk issues but surface water flood risk on flow path from the south west with risk areas to the south of the station and on Langley Park Rd under rail lines
Uxbridge	Small proportion within the floodplains of the Frays River, River Colne and Grand Union Canal which flow through the Town Centre. Some localised areas of surface water risk identified, notably along rail lines just outside Station
Wood Green	Particular flood risk from Moselle Brook culvert. Relatively minor surface water flood risks, mainly focused on the public highway network with higher risk areas to the west of the National Rail lines
Major centres	
	Flood Risk Issues
Angel	Regents Canal flows in a tunnel under the Town Centre. No identified fluvial flood risk issues but some localised surface water risks.
Barking	No identified fluvial flood risk issues, but some localised surface water risks
Bexleyheath	No identified fluvial flood risk issues, but some localised surface water risks to the west of the town centre
Brixton	Significant surface water flood risk identified through the town centre along the course of the Lost River Effra and continuing north along Brixton Road
Camden Town	Grand Union Canal flows through the Town Centre. No identified fluvial flood risk issues but some localised surface water risks. Opportunities to discharge surface water to the canal
Canary Wharf	Wholly within the Thames tidal floodplain but protected by the Thames tidal defences. Opportunities to discharge surface water to the docks.

Catford	Partially within floodplain of the River Ravensbourne with significant areas of surface water risk along the Ravensbourne corridor
Chiswick	Wholly within the River Thames floodplain - both tidal and fluvial flood risk and some localised surface water risk areas
Clapham Junction	Small proportion within the River Thames floodplain and significant surface water flood risk identified through the town centre along Northcote Rd, St Johns Rd, under railway and affecting a large area to the north of rail lines
Dalston	No identified fluvial flood risk issues, but some localised surface water risks, notably the sub-surface London Overground rail lines
East Ham	No identified flood risk issues
Edgware	Partially within the Silk Stream floodplain with some significant surface water risk areas following the corridors of small local tributary rivers
Eltham	No identified fluvial flood risk issues, but some surface water risks around Well Hall Parade and risks to the A2 below the town centre
Enfield Town	No identified fluvial flood risk issues, but some significant surface water flood risks
Fulham	Wholly within the Thames tidal floodplain but protected by the Thames tidal defences, some localised surface water risks
Hammersmith	Almost entirely within the Thames tidal floodplain but protected by the Thames tidal defences, some areas of surface water flood risk, notably on roads under rail to the north of King St.
Kensington High Street	No identified flood risk issues
Kilburn	No identified fluvial flood risk issues, but some localised surface water risks, mainly affecting public highway
Kings Road East	Small proportion within the River Thames floodplain but well defended
Lewisham	Substantially within the floodplains of the Rivers Ravensbourne and Quaggy with significant areas of surface water risk along the floodplains
Nags Head	No identified fluvial flood risk issues, but some localised surface water risk areas
Orpington	Significantly within the River Cray floodplain with extensive surface water flood risk areas along Sevenoaks Rd- Orpington High St corridor
Peckham	No identified fluvial flood risk issues, but some significant surface water risks, notably to the east of the town centre along the Copeland Rd-Clayton Rd corridor
Putney	Small proportion within the Thames tidal floodplain but protected by Thames Tidal Defences including the Thames Barrier
Queensway/Westbourne Grove	No identified fluvial flood risk issues, but some localised surface water flood risk areas, notably affecting basements
Richmond	Small proportion within the Thames floodplain, some localised surface water risk areas around The Quadrant and affecting the sub surface rail station
Southall	No identified fluvial flood risk issues, but some localised surface water risk areas
Streatham	No identified fluvial flood risk issues, but a significant area of surface water flood risk to the north east of Streatham Station
Tooting	No identified fluvial flood risk issues, but some localised surface water risks, possibly focused on the route of the River Graveney
Walthamstow	No identified fluvial flood risk issues, but some localised surface water flood risk areas
Wandsworth	Significantly within the tidal Thames and River Wandle floodplains and the River Wandle flows through the Town Centre and some significant surface water risk areas focused on the Wandle Floodplain and roads passing under the railway
Wembley	No identified fluvial flood risk issues. Wembley Brook flows in a culvert under part of the Town Centre and some localised surface water risks notably to the east of Lancelot Rd

Wimbledon	No identified fluvial flood risk issues, but some risks to below ground level railway
Woolwich	Partially within the River Thames floodplain and some significant surface water risk areas

Recommendation 7 – Flood Risk to Opportunity Areas and Town Centres
Where required, detailed flood risk assessments for individual major development locations and town centre development sites should be undertaken by developers at an early stage. Opportunities to reduce flood risk should be maximised where possible.

3.3 Main Rail Network and Major Stations

162. Map 4 shows that there are a total of 85 mainline stations and 87 km of mainline rail corridor at high risk of tidal/fluvial and/or surface water flooding. This represents 24 per cent of London's stations and 11 per cent of its rail corridor. A key issue is also the vulnerability of power supplies, signalling and communications equipment to flood risk.

163. Rail lines cross rivers on bridges, viaducts and embankments. Here the routes are generally at low flood risk. Examples include the elevated rail lines through London Bridge and into Waterloo, Blackfriars and Victoria. Many stations are also on elevated sections of track and therefore at lower risk. The rail lines into Liverpool Street and Stratford along the Lee Valley and the C2C lines east of Barking travel through the River Lee and Thames floodplains respectively often at ground level. These have a higher level of flood risk. Rail services within cuttings or stations with large roof areas may be at particular risk from surface water flooding during heavy storms and these are set to increase.

3.4 London Underground & DLR Networks

164. Map 5 shows that 4 per cent of the London Underground and DLR stations and 9 per cent of the lines are at risk of tidal/fluvial and/or surface water flooding. The majority of high-risk stations are within the tidal Thames floodplain through central London and westwards. The stations on the DLR branch to Stratford and Jubilee line from Stratford to Canning town are also within the River Lee Fluvial floodplain. However, most of the DLR network at flood risk is elevated on raised tracks. There are also some outlying stations and tracks, which are in the floodplain and/or at risk of surface water flooding. However, notable sections of the tube network are also on raised tracks including for example parts of the District Line (Hammersmith to Acton, Putney Bridge to Wimbledon, around West Ham) as well as Outer London parts of the Central, Piccadilly, Northern and Metropolitan Line.

165. Flood water getting into underground stations presents a particular hazard and a major engineering problem if the flood waters were to enter tube tunnels. This risk is extended geographically as tunnel portals could act as a conveyance route for flood water from a wide variety of locations, especially in the event of a tidal flood. The tube and DLR lines listed in Table 3 have **tunnel portals** within floodplains:

Table 3: Tunnel Portals in Floodplain

Tube Line	Tunnel Portal	Floodplain
Central Line	Eastern Portal	River Lee
London Overground	Southern Portal	Tidal Thames
Jubilee Line	Eastern Portal	Tidal Thames
Victoria Line	Northern Portal	River Lee
DLR Lewisham branch	Thames Tunnel both portals	Tidal Thames
DLR Woolwich branch	Thames tunnel both portals	Tidal Thames

166. It is acknowledged that the underground location of stations and tracks means that the flood risk may not necessarily be highest in the corresponding flood risk areas of the ground. This is why the portals are highlighted, and there may also be other potential flood routes including emergency access points and ventilation shafts.

167. London Underground has undertaken a review of flood risk from all sources that may affect its lines, stations, depots and other infrastructure. London Underground is using the results of this work to prioritise appropriate flood risk mitigation works over the coming years. They have also identified measures to mitigate the risks and consequences of burst water mains.

168. In addition, TfL is preparing a work programme related to improving the understanding of transport resilience in London. A Transport Sector working group is being established, also in line with related draft policies set out in the draft London Environment Strategy[38] and Mayor's Transport Strategy[39].

3.5 Main Road Network and Airports

169. The road network is a critical element of London's infrastructure. The bus network provides around 6.5 million journey stages per day[40] and much of the network is heavily used by private passenger and goods vehicles. The road network is also of critical importance to emergency services. The road network is managed by a combination of Highways England for motorways and some trunk roads, TfL for the Transport for London road network (TLRN) and local boroughs for local roads. The density of the road network in London is likely to mean that alternative routes will be available in localised flood situations. However the volume of traffic is likely to lead to significant congestion.

170. Map 6 shows that 11 per cent of the TLRN are at high risk, the majority of which is in the tidal floodplain. However, some important road sections including parts of the A13 and the North Circular are elevated, and TfL has a pro-active monitoring programme of its network to report on flooding incidents, assess risks and implement remedial measures.

171. **Tunnels under the Thames** have a particular risk as their portals are all within the tidal Thames floodplain. In a similar way to tube tunnels, ventilation shafts or emergency shafts may also present potential routes for the conveyance of flood water.

[38] Policy 8.1.1

[39] Policy 8 and Proposals 44 and 45

[40] For details see https://tfl.gov.uk/corporate/publications-and-reports/travel-in-london-reports

Other underpasses are low points within the road network and are more likely to be at risk of surface water flooding, and a few are also within a Flood Zone.

Subterranean river crossings (road and pedestrian)
Rotherhithe Tunnel
Limehouse Link Tunnel
Greenwich Foot Tunnel
Blackwall Tunnel x2
Woolwich Foot Tunnel
Proposed: Silvertown Crossing

Road Underpasses
A501 Euston Road
A406 Edmonton – River Lee Floodplain
A406 Stonebridge Park
A406 Crooked Billet
A12 Wanstead/Green Man junction
A102/A11 Bow – River Lee Floodplain
A13 Movers Lane – River Thames Floodplain
A113/A1400 Charlie Browns Roundabout – River Roding Floodplain
A4088 Neasden Lane /A406 underpass
A4 Hyde Park Corner underpass
A214 Trinity Road/East Hill Underpass
A3 Tibbetts Corner underpass
A3 Tolworth Underpass
A3 Hook Road underpass
Heathrow Access Road

Bus Depots

172. Some of the bus garages serving London's bus operators are within flood risk areas. A flood affecting a garage may have the direct impact of making buses unusable or may have other indirect impacts for example the loss of electricity supply rendering fuel pumps inactive or employees who are unable to reach work.

173. Bus depot flood management measures could include ideally a combination of green and blue roofs. There is a good practice example at West Ham, where also rainwater is captured for use in vehicle washing.

Airports

174. **Heathrow Airport** is largely free from flood risk, although some of the peripheral areas to the west of the airport could be affected by large floods on the River Colne system. The airport has large surface water attenuation areas.

175. **London City Airport** is wholly within the floodplain of the tidal Thames. It is in an area that is close to the Thames Barrier. It is protected by the existing flood defences to a standard of at least 1 in 1000 years.

Recommendation 8 – Flood Risk to Transport Infrastructure
Relevant transport authorities and operators should examine and regularly review their infrastructure assets including their networks, stations, depots, underpasses and tunnels for potential flooding locations and flood risk reduction measures.
Appropriate mitigation measures include flood warning systems, emergency procedures, sustainable drainage systems, temporary flood storage areas, pumping stations, back-up power supply and the relocation of sensitive electrical/telecommunications equipment and potentially polluting materials (e.g. fuel and oils) above potential flood levels.
For large stations and depots, solutions should be sought to attenuate or disperse rainwater from heavy storms including in particular a comination of green and blue roofs.
Highways flood management measures should also include diversionary routes.
For tunnel portals and ventilation shafts physical barriers such as flood gates and vent covers should be considered.

3.6 Hospitals and Emergency Services

176. The London Resilience Partnership updated in 2015 its London Strategic Flood Response Framework[41]. It is important for emergency services to remain operable during major flood events. Localised flooding events should be able to be managed by other supporting emergency services. Major flood events affecting either the tidal Thames or the major tributaries will need consideration and co-operation between several services. This RFRA has identified potentially vulnerable concentrations of emergency service facilities within flood risk areas.

Main Hospitals

177. 43 per cent of the 191 hospitals are at high risk of tidal/fluvial and/or surface water flood risk (see Map 7). This is a high proportion, and therefore mitigation measures such as those included in Recommendation 9, are important. But it should also be recognised that this is a precautionary approach. Many hospitals are large complex building structures, and without further analysis it is very difficult to know, if important parts that could put people or the running of the hospitals at risk might be affected. In many cases it may only be small areas.

178. **Drain London** commissioned some more detailed reviews of surface water risk to hospitals. This work demomstrated that they were generally able to manage their risks at an acceptable level.

Fire Stations

179. Fire stations are likely to be important bases during flood events. Map 8 indicates that 28 fire stations from a total of 118 within London (24 per cent) are at high risk of fluvial/tidal and/or surface water flooding. Several are in the central/inner London Thames tidal floodplain and as such have a high degree of flood protection in particular from tidal flooding. They are also generally well covered by other fire stations just outside the Flood Zone.

[41] For details see www.london.gov.uk/about-us/organisations-we-work/london-prepared/planning-emergencies-capital#acc-i-43126

180. **Drain London** identified eight fire stations at risk of surface water flooding and commissioned more detailed reviews of those stations and their risks. The more detailed work revealed that two fire stations had a significant risk of surface water flooding, and this information has been shared with London Fire Brigade.

Ambulance Stations

181. Map 8 also indicates that 12 of London's 64 ambulance stations (19 per cent) are at high risk of fluvial/tidal and/or surface water flooding. Several are in the central/inner London Thames tidal floodplain and as such have a high degree of flood protection in particular from tidal flooding. They are also generally well covered by other ambulance stations just outside the Flood Zone.

182. **Drain London** identified three ambulance stations with a potentially significant risk of surface water flooding.

Police Stations

183. Map 8 also indicates that 58 of London's 235 police stations (25 per cent) are at high risk of fluvial/tidal and/or surface water flooding. They are generally well covered by other police stations just outside the Flood Zone.

184. **Drain London** identified three police stations with a potentially significant risk of surface water flooding.

Prisons

185. Finally, Map 8 also indicates that 3 of London's 39 prisons (8 per cent) are at high risk of fluvial/tidal and/or surface water flooding. Several are within the tidal Thames floodplain and as such have a high degree of flood protection in particular from tidal flooding. However, in the event of a flood issues of safety and security would arise, and therefore detailed emergency plans should be in place for the event of a flood.

Recommendation 9 – Flood Risk to Emergency Services
Emergency service authorities and operators covering hospitals, ambulance, fire and police stations as well as prisons should ensure that emergency plans in particular for facilities in high flood risk areas are in place and regularly reviewed, so that they can cope in the event of a major flood. These plans should put in place cover arrangements through other suitable facilities.

3.7 Schools

186. Schools need to serve their local population. Map 9 indicates that 643 of London's 2,895 schools[42] (22 per cent) are either wholly or partially at risk of fluvial/tidal and/or surface water flooding, although for some of them it may only be to a minor extent, for example within playing fields. Many of schools affected are in central/inner London part of the Thames tidal floodplain and as such have a high degree of flood protection. However, a flood could represent a direct risk to the pupils and staff at schools and could cause longer-term disruption whilst any repairs are made.

[42] Types of schools include Primary, Secondary, All Through, and 16 Plus.

187. Schools are also important in terms of **managing civil emergencies** as they are often used as emergency shelter, food and supply bases. If the emergency is a flood, then this may mean that the school cannot fulfil this function.

188. **Drain London** examined secondary schools across London and identified 21 secondary schools at significant risk of surface water flooding. Consultants investigated these risks in more detail and found that ten sites had the most significant risks. For each of these sites the consultants discussed potential mitigation option with the schools and presented a range of relatively low impact proposals.

Recommendation 10 – Flood Risk to Schools
Education authorities should ensure that emergency plans in particular for facilities in flood risk areas are in place and regularly reviewed so that they can cope in the event of a major flood. These plans should put in place cover arrangements through other suitable facilities.

3.8 Utilities

189. This section covers a wide range of utility installations including electricity supply, gas supply, telecommunications, sewage disposal, and water supply. The data about utilities is much more accurate and up-to-date compared to the previous RFRA. Map 10 provides a spatial overview showing 261 of 587 sites (44 per cent) at high risk of flooding. This is a relatively significant proportion, and therefore mitigation measures such as those included in Recommendation 11, are important. But it should also be recognised that many different types of utilities are included and several sites are likely to be large complex structures. Without further analysis it is very difficult to know, if important parts that could put their operation at risk might be affected.

190. It should also be noted that the flood risk Policy SI12 in the new draft London Plan explicitly includes the following clause E: 'Development proposals for utility services should be designed to remain operational under flood conditions and buildings should be designed for quick recovery following a flood.'

191. The following sections address individual utilities in more detail.

Major Electrical Installations

192. Many power generation plants are located near rivers or the sea as they require large volumes of water for cooling purposes. Therefore, they have an associated flood risk. Most of London's electricity supply is generated outside London and transmitted to London via high voltage power lines, either on pylons or underground. London does still have some energy generation capability and also many switching and transformer stations. Major installations in floodplains, potentially affected by flooding from rivers and/or the sea, are listed in Table 4.

Table 4: Electrical Installations in Floodplain

Installation	Floodplain
Brimsdown Power Station	Adjacent to River Lee floodplain
Barking Power Station	Wholly within the Thames Tidal floodplain
Greenwich Power Station	Wholly within the Thames Tidal floodplain
Croydon/Beddington Switching Station	Partially within River Wandle floodplain
Edmonton Waste to Energy	Wholly within River Lee floodplain
SELCHP Waste to Energy	Wholly within the Thames Tidal floodplain
Belvedere Waste to Energy	Wholly within the Thames Tidal floodplain

Major Gas Installations

193. Gasholders and pipelines are unlikely to be directly affected by a flood given that they are gas tight containers and therefore will not let water in. However, in the unlikely event of water entering a gasholder, drying it out again is a difficult and costly process. There may also be issues around ancillary power and access to gas sites.

Water and Sewage Treatment Plants

194. Water and sewage treatment plants are naturally located close to major rivers in order to abstract water from them and discharge treated sewage effluent into them. It is therefore to be expected that these plants are exposed to a certain level of flood risk.

195. A significant flood at a **water treatment plant** could result in the contamination of drinking water supplies by flood water. This risk may trigger the shutting down of the plant. The operation of the plant may also be affected by ancillary power losses. However, the London Ring Main ensures that water supplies can be flexibly managed and supplies derived from several works. Given the geographical spread of the works, they are unlikely all to be affected by one flood. In addition, the four water companies supplying London with drinking water all have operational plans to cope with flooding. Major plants in floodplains, potentially affected by flooding from rivers and/or the sea, are listed in Table 5.

Table 5: Water Treatment Plants in Floodplain

Water treatment plant	Flood Risk Zone
Hampton	Substantially within River Thames floodplain
Coppermills	Partially within River Lee floodplain
Walton (outside London but supplying parts of London)	Partially within River Thames floodplain

196. Thames Water operates all the **sewage treatment works** in London and has operational plans to cope with flooding. A significant flood at a sewage treatment plant could result in the contamination of rivers and land as the flood spreads untreated or partially treated sewage and effluent from the works. The operation of the works may also be affected by ancillary power losses. Major plants in floodplains, potentially affected by flooding from rivers and/or the sea, are listed in Table 6.

Table 6: Sewage Treatment Plants in Floodplain

Sewage Works	Floodplain
Beckton	Wholly within the Thames Tidal floodplain
Crossness	Wholly within the Thames Tidal floodplain
Riverside	Wholly within the Thames Tidal floodplain
Deephams	Substantially within River Lee floodplain
Beddington Farm	Partially within River Wandle floodplain
Hogsmill	Substantially within Hogsmill Brook floodplain
Luxborough Lane (outside London but treats sewage from parts of London)	Wholly within River Roding floodplain
Long Reach (outside London but treats sewage from parts of London)	Wholly within the Thames Tidal floodplain

197. In addition to the listed water treatment and sewage works there may also be pumping stations and other installations that relate to water infrastructure. There are also a number of pumping stations to manage surface water. These are particularly relevant to low lying areas such as Thamesmead.

Waste Management Sites

198. As London has a high number of waste management sites and as a specific online tool is available (the London Waste Map[43]), waste management has been separated from the other utitilies. Map 11 is based on the London Waste Map and shows 164 of 312 sites (34 per cent) at high risk of flooding. This is a relatively significant proportion, and therefore mitigation measures such as those included in Recommendation 11, are important. But it should also be recognised that this is a precautionary approach. Many different types of waste management are included and several sites are likely to be large complex structures. Without further analysis it is very difficult to know, if important parts that could put their operation at risk might be affected. In many cases it may only be small areas.

Recommendation 11 – Flood Risk to Utility Infrastructure
Operators of electricity, gas, water, sewerage, and waste utility sites should maintain an up to date assessment of the flood risk to their installations and, considering the likely impacts of failure, establish any necessary protection measures including flood warning, emergency procedures, sustainable drainage systems and secondary flood defences.

3.9 Other Sites

199. This RFRA is not intended to provide a comprehensive list of all vulnerable assets. Other vulnerable land uses include **nursing homes**, where the safety and ability to evacuate residents may be difficult, and **council/benefits offices**, where closure would have an immediate impact on the welfare of local communities, particularly the most vulnerable. **COMAH sites, petrol stations and other sources of pollution** are also particular risks, as flood water may liberate and spread polluting and/or dangerous substances that could have further impacts over and above the physical impacts of the flood waters.

[43] For details see https://maps.london.gov.uk/waste/

Chapter 4 – Conclusions and Look Ahead

200. Flood Risk is a serious issue for London. It is important that the capital's future is planned for and delivered in the fullest knowledge of flood risk and how it is likely to change in future. That knowledge is advancing rapidly and it will be important to keep this RFRA under regular review.

201. The application of the relevant draft London Plan policies – in particular Policies SI12 and SI13 – will be required to **sustainably manage flood risk through new development**. New development represents one of the key opportunities to reduce overall flood risk, notably through improved management of surface water, setting development back from the waterways and allowing space for future maintenance and upgrade of flood defences. The planning of the major development locations and town centres, where the majority of the anticipated growth will be located, which increases the potential consequences of flood events, will have to address flood risk in more detail. This RFRA provides an updated overview of broad flood risk issues in each of these locations and a framework of potential mitigation measures on which the relevant partners can build locally. In terms of flood risk for London's key infrastructure and services this RFRA illustrates these risks spatially and identifies mechanisms to investigate, monitor and address flood risk of current and new infrastructure and services in cooperation with relevant partners.

202. This RFRA includes a revised set of **monitoring recommendations**, which will be used to keep the information up-to-date and to ensure regular checks on broad mitigation measures. This will also help to focus attention on the strategic issues relating to flood risk in London. Progress against the recommendations will continue to be monitored in the London Plan Annual Monitoring Report. Since the publication of the original 2009 RFRA progress against the recommendations reflects in particular the actions of Drain London in terms of the improved understanding of surface water flood risk. Improvements to local flood risk policies based on completed and updated Strategic Flood Risk Assessments (SFRAs) are also apparent. More widely, the London Climate Change Partnership is working on climate change adaptation indicators for London and a sector-based assessment of how the capital is coping with the challenge.

203. It should also be noted that the Mayor has established a **new Water Advisory Group** to provide advice on water management issues in London including:

- water resources/supplies and use
- flood risk and drainage
- sewerage and water quality
- integration across these areas, resilience and innovation.

204. Its remit includes the coordination of activities between key stakeholders and to maintain awareness of potential water management risks (such as floods, droughts, major pollution incidents) and to help coordinate action in response to the lead up, management and recovery from such events.

205. This draft of the Regional Flood Risk Appraisal is published for **public consultation until 2 March 2018**. Consultees are particularly invited to review and add strategic area-specific information to ensure local accuracy. Following consultation, the GIS layers for the risk receptors will also be placed on the London Datastore.

Appendix 1 List of Monitoring Recommendations

Recommendation 1 – Tidal Flood Risk
The London boroughs should address relevant tidal flood risk mitigation measures set out in the Thames Estuary 2100 Plan in their Local Plans. They include setting back development and defences from the banks of watercourses, flood storage and flood gates.
The delivery of Riverside Strategies through Thames Estuary 2100 should be supported.

Recommendation 2 – Fluvial Flood Risk
Regeneration and redevelopment on London's river corridors offer a crucial opportunity to reduce fluvial flood risk. Strategic Flood Risk Assessments (SFRA) and planning policies should focus on making the most of this opportunity through appropriate location, layout and design of development as set out in the Thames Catchment Flood Management Plan (CFMP). In particular opportunities should be sought to set back development from the river edge; ensure that developments with residual flood risk are designed to be flood compatible and/or flood resilient; and maximise the use of open spaces to make space for flood water.

Recommendation 3 – Surface Water Flood Risk
Developments all across London should reduce surface water discharge in line with the Sustainable Drainage Hierarchy set out in Policy SI13 of the London Plan, and the actions in the London Sustainable Drainage Action Plan (LSDAP) should also be taken.

Recommendation 4 – Sewer Flood Risk
Thames Water should continue the programme of addressing foul sewer flooding, also working with other risk management authorities such as local authorities and the Environment Agency.

Recommendation 5 – Groundwater Flood Risk
The groundwater flood risk in identified locations (see IPEG map) should be considered in Strategic Flood Risk Assessments (SFRAs) and Flood Risk Assessments (FRAs).

Recommendation 6 – Reservoir Flood Risk
The reservoir flood risk in identified locations (see reservoir flood map) should be considered in Strategic Flood Risk Assessments (SFRAs) and Flood Risk Assessments (FRAs).

Recommendation 7 – Flood Risk to Opportunity Areas and Town Centres
Where required, detailed flood risk assessments for individual major development locations and town centre development sites should be undertaken by developers at an early stage. Opportunities to reduce flood risk should be maximised where possible.

Recommendation 8 – Flood Risk to Transport Infrastructure
Relevant transport authorities and operators should examine and regularly review their infrastructure assets including their networks, stations, depots, underpasses and tunnels for potential flooding locations and flood risk reduction measures.
Appropriate mitigation measures include flood warning systems, emergency procedures, sustainable drainage systems, temporary flood storage areas, pumping stations, back-up power supply and the relocation of sensitive electrical/telecommunications equipment and potentially polluting materials (e.g. fuel and oils) above potential flood levels.
For large stations and depots, solutions should be sought to attenuate or disperse rainwater from heavy storms including green roofs.
Highways flood management measures should also include diversionary routes.
For tunnel portals and ventilation shafts physical barriers such as flood gates and vent covers should be considered.

Recommendation 9 – Flood Risk to Emergency Services
Emergency service authorities and operators covering hospitals, ambulance, fire and police stations as well as prisons should ensure that emergency plans in particular for facilities in high flood risk areas are in place and regularly reviewed, so that they can cope in the event of a major flood. These plans should put in place cover arrangements through other suitable facilities.

Recommendation 10 – Flood Risk to Schools
Education authorities should ensure that emergency plans in particular for facilities in flood risk areas are in place and regularly reviewed so that they can cope in the event of a major flood. These plans should put in place cover arrangements through other suitable facilities.

Recommendation 11 – Flood Risk to Utility Infrastructure
Operators of electricity, gas, water, sewerage, and waste utility sites should maintain an up to date assessment of the flood risk to their installations and, considering the likely impacts of failure, establish any necessary protection measures including flood warning, emergency procedures, sustainable drainage systems and secondary flood defences.

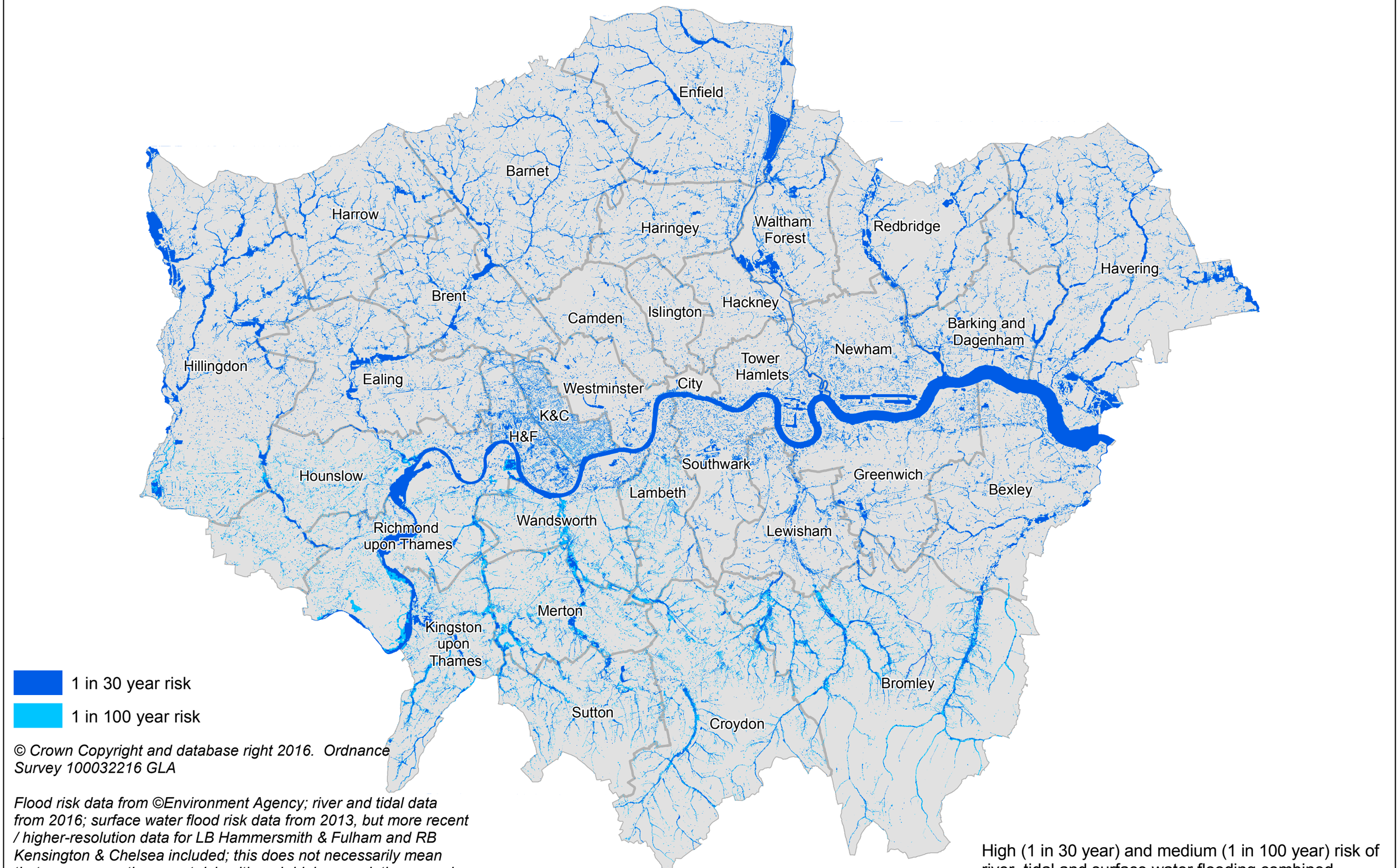
Appendix 2 - Abbreviations

CAZ	Central Activities Zone
CFMP	Catchment Flood Management Plan
EA	Environment Agency
F&WM Act	Flood and Water Management Act
FRA	Flood Risk Assessment
FRMP	Flood Risk Management Plan
GLA	Greater London Authority
IPEG	Indicative Potential for Elevated Groundwater
LB	London borough
LLFA	Lead Local Flood Authority
LSDAP	London Sustainable Drainage Action Plan
LSFP	London Strategic Flood Plan
NPPF	National Planning Policy Framework
PPG	Planning Practice Guidance
RFRA	Regional Flood Risk Appraisal
SFRA	Strategic Flood Risk Assessment
SHLAA	Strategic Housing Land Availability Assessment
SuDS	Sustainable Drainage System
SWMP	Surface Water Management Plan
TE2100	Thames Estuary 2100 Plan
TfL	Transport for London
TLRN	Transport for London Road Network

Appendix 3 – Flood Risk Maps

Appendix 3 – Flood Risk Maps

Map 1 - Environment Agency Flooding From Multiple Sources in Greater London 2017



Flood risk data from ©Environment Agency; river and tidal data from 2016; surface water flood risk data from 2013, but more recent / higher-resolution data for LB Hammersmith & Fulham and RB Kensington & Chelsea included; this does not necessarily mean that more properties are at risk, although higher resolution may give that impression on this London-wide map

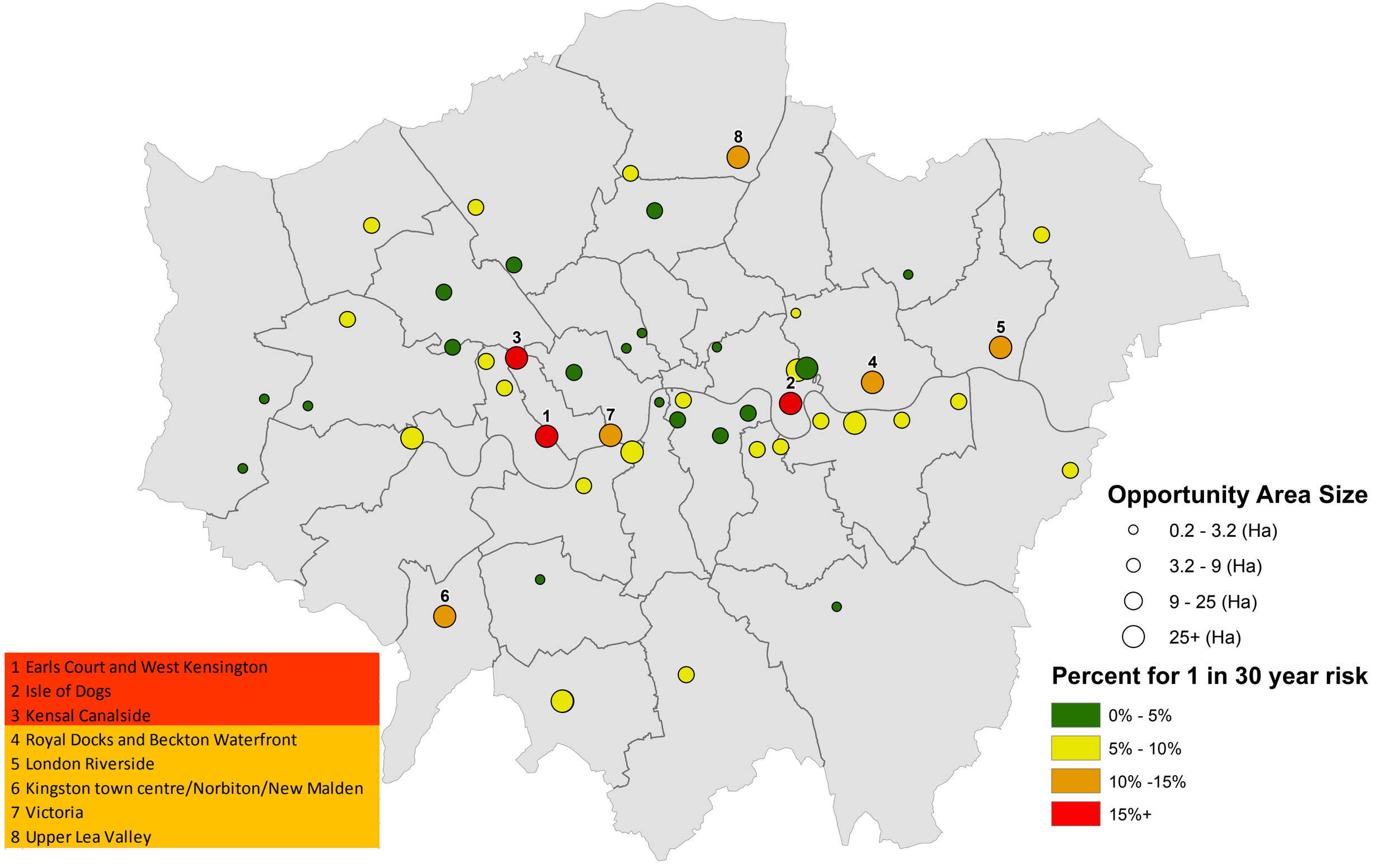
High (1 in 30 year) and medium (1 in 100 year) risk of river, tidal and surface water flooding combined (basis for other maps in this RFRA)

Environment Agency Flooding From Multiple Sources in Greater London 2017

NAME	Area in 1 in 30 Flood: High Risk (Ha)	Area in 1 in 100 Flood: Medium Risk (Ha)	TOTAL AREA (Ha)	PORTION IN 1 IN 30 FLOOD RISK	PORTION IN 1 IN 100 FLOOD RISK
Barking and Dagenham	367	620	3,780	10%	16%
Barnet	396	504	8,675	5%	6%
Bexley	657	923	6,429	10%	14%
Brent	222	450	4,323	5%	10%
Bromley	401	1,035	15,013	3%	7%
Camden	38	98	2,179	2%	4%
City of London	33	38	315	11%	12%
Croydon	199	546	8,649	2%	6%
Ealing	279	524	5,554	5%	9%
Enfield	540	1,003	8,220	7%	12%
Greenwich	502	626	5,044	10%	12%
Hackney	51	143	1,905	3%	8%
Hammersmith and Fulham	308	343	1,715	18%	20%
Haringey	95	264	2,960	3%	9%
Harrow	207	383	5,046	4%	8%
Havering	1,089	1,692	11,446	10%	15%
Hillingdon	841	1,395	11,570	7%	12%
Hounslow	247	406	5,659	4%	7%
Islington	24	81	1,486	2%	5%
Kensington and Chelsea	197	275	1,238	16%	22%
Kingston upon Thames	226	429	3,726	6%	12%
Lambeth	119	222	2,725	4%	8%
Lewisham	170	387	3,532	5%	11%
Merton	158	392	3,762	4%	10%
Newham	488	785	3,858	13%	20%
Redbridge	313	587	5,644	6%	10%
Richmond upon Thames	644	891	5,876	11%	15%
Southwark	233	285	2,991	8%	10%
Sutton	128	305	4,385	3%	7%
Tower Hamlets	289	345	2,157	13%	16%
Waltham Forest	311	523	3,881	8%	13%
Wandsworth	225	391	3,522	6%	11%
Westminster	162	261	2,203	7%	12%
TOTALS	*10,161*	*17,150*	*159,470*	*6%*	*11%*

Flood risk data from ©Environment Agency; river and tidal data from 2016; surface water flood risk data from 2013

Map 2 - Opportunity Areas and Flood Risk 2017

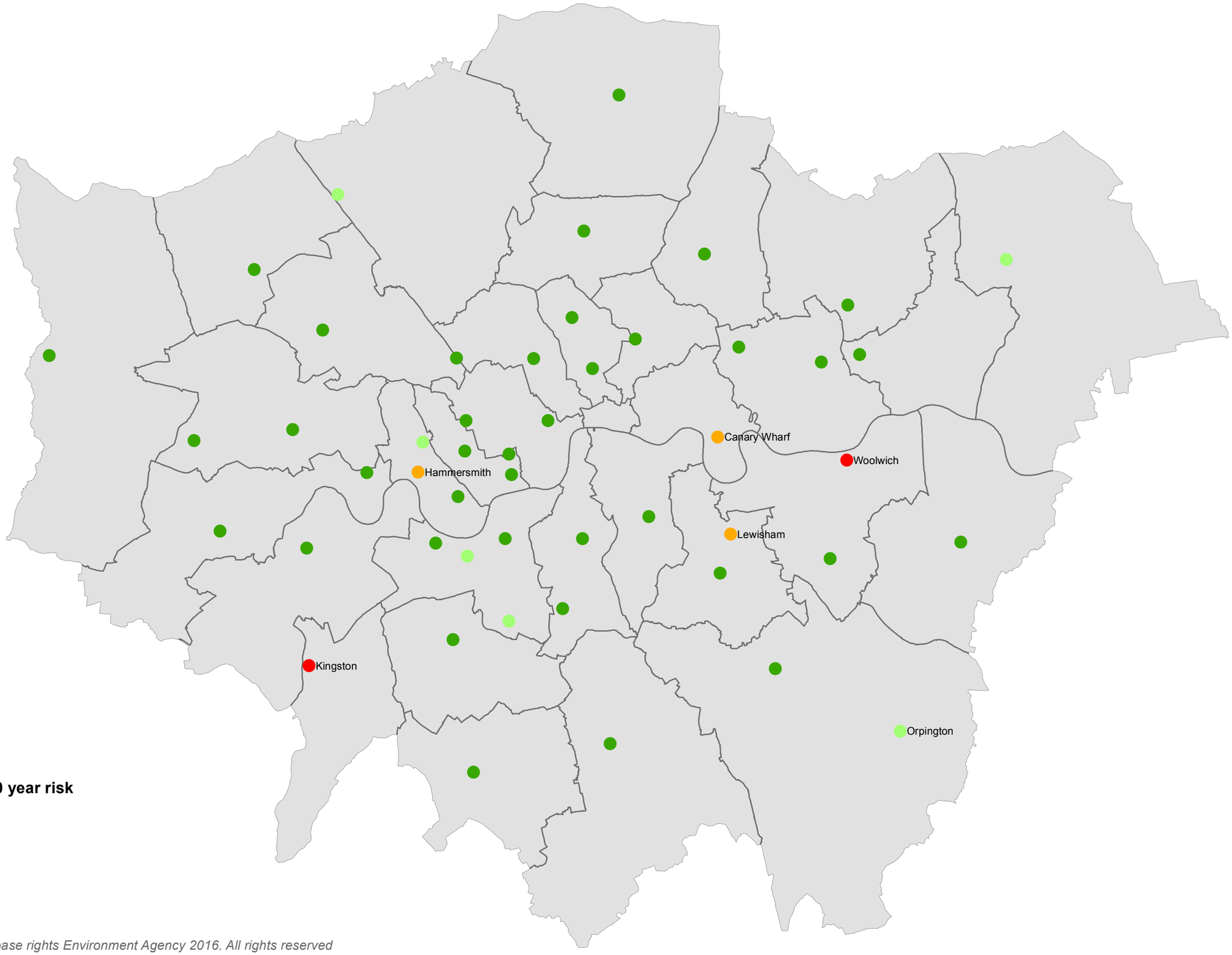


Corresponding Table also includes data for 1 in 100 and 1 in 1000 year flood risk for each Opportunity Area.

Opportunity Areas and Flood Risk 2017

NAME	Area in 1 in 1000 (Ha)	Portion in 1 in 1000	Area in 1 in 100 (Ha)	Portion in 1 in 100	Area in 1 in 30 (Ha)	Portion in 1 in 30	Opportunity Area (Ha)
Bexley Riverside	807	60%	153	11%	108	8%	1353
Bromley	9	13%	5	7%	2	2%	69
Canada Water	33	72%	2	4%	2	4%	46
Charlton Riverside	138	78%	21	12%	16	9%	177
City Fringe/ Tech City	147	16%	49	5%	19	2%	898
Clapham Junction	38	65%	4	7%	3	5%	59
Colindale/Burnt Oak	61	23%	38	14%	22	8%	262
Cricklewood/Brent Cross	59	18%	18	6%	13	4%	324
Croydon	33	17%	33	17%	10	5%	194
Deptford Creek/Greenwich Riverside	125	77%	18	11%	13	8%	163
Earls Court and West Kensington	28	74%	7	18%	6	17%	38
Elephant and Castle	87	99%	4	5%	3	4%	88
Euston	14	16%	5	5%	1	2%	85
Golden Mile/ Great West Corridor	98	25%	57	15%	35	9%	391
Greenford	32	20%	17	11%	8	5%	160
Greenwich Peninsula	225	86%	18	7%	16	6%	261
Haringey Heartlands/Wood Green	11	19%	6	10%	2	4%	60
Harrow & Wealdstone	31	18%	20	11%	10	6%	177
Hayes HZ	37	8%	12	3%	3	1%	462
Heathrow	1155	17%	490	7%	238	4%	6788
Ilford	15	17%	5	5%	1	1%	85
Isle of Dogs	463	95%	84	17%	76	16%	488
Kensal Canalside	5	28%	4	21%	3	15%	20
King's Cross - St Pancras	9	18%	4	8%	2	3%	53
Kingston town centre/Norbiton/New Malden	129	32%	63	15%	42	10%	405
Lewisham, Catford & New Cross	353	43%	145	18%	61	7%	818
London Bridge, Borough & Bankside	155	99%	8	5%	8	5%	156
London Riverside	1236	50%	680	27%	301	12%	2474
Lower Lea Valley	161	72%	45	20%	14	6%	224
New Southgate	119	17%	75	11%	36	5%	693
Old Kent Road	343	27%	148	12%	55	4%	1282
Old Oak Common	252	89%	21	7%	19	7%	282
Olympic Legacy SPG boundary	41	17%	28	12%	20	8%	240
Paddington	7	19%	5	14%	1	4%	38
Park Royal	68	16%	35	8%	15	4%	415
Poplar Riverside	73	15%	24	5%	14	3%	480
Romford HZ	71	23%	32	11%	16	5%	308
Royal Docks and Beckton Waterfront	1086	83%	316	24%	188	14%	1302
Southall	76	14%	24	5%	7	1%	523
Sutton	9	25%	5	16%	3	9%	34
Thamesmead & Abbey Wood	707	81%	61	7%	57	6%	877
Tottenham Court Road	2	12%	0	3%	0	0%	19
Upper Lea Valley	1808	36%	950	19%	517	10%	5024
Vauxhall, Nine Elms & Battersea	218	96%	25	11%	21	9%	227
Victoria	43	83%	6	12%	5	10%	51
Waterloo	78	100%	3	4%	3	3%	78
Wembley	59	25%	27	11%	10	4%	239
White City	20	18%	11	10%	7	7%	107
Wimbledon	4	16%	3	10%	1	3%	29
Woolwich	22	33%	6	9%	3	5%	66
TOTAL	*10801*	*37%*	*3821*	*13%*	*2037*	*7%*	*29090*

Map 3 - Town Centres and Flood Risk 2017



percent for 1 in 30 year risk

- 0-8
- 8-16
- 16-24
- 24-34

Town Centres from GLA Town Centre Health Check

International, Metropolitan and Major Town Centres included

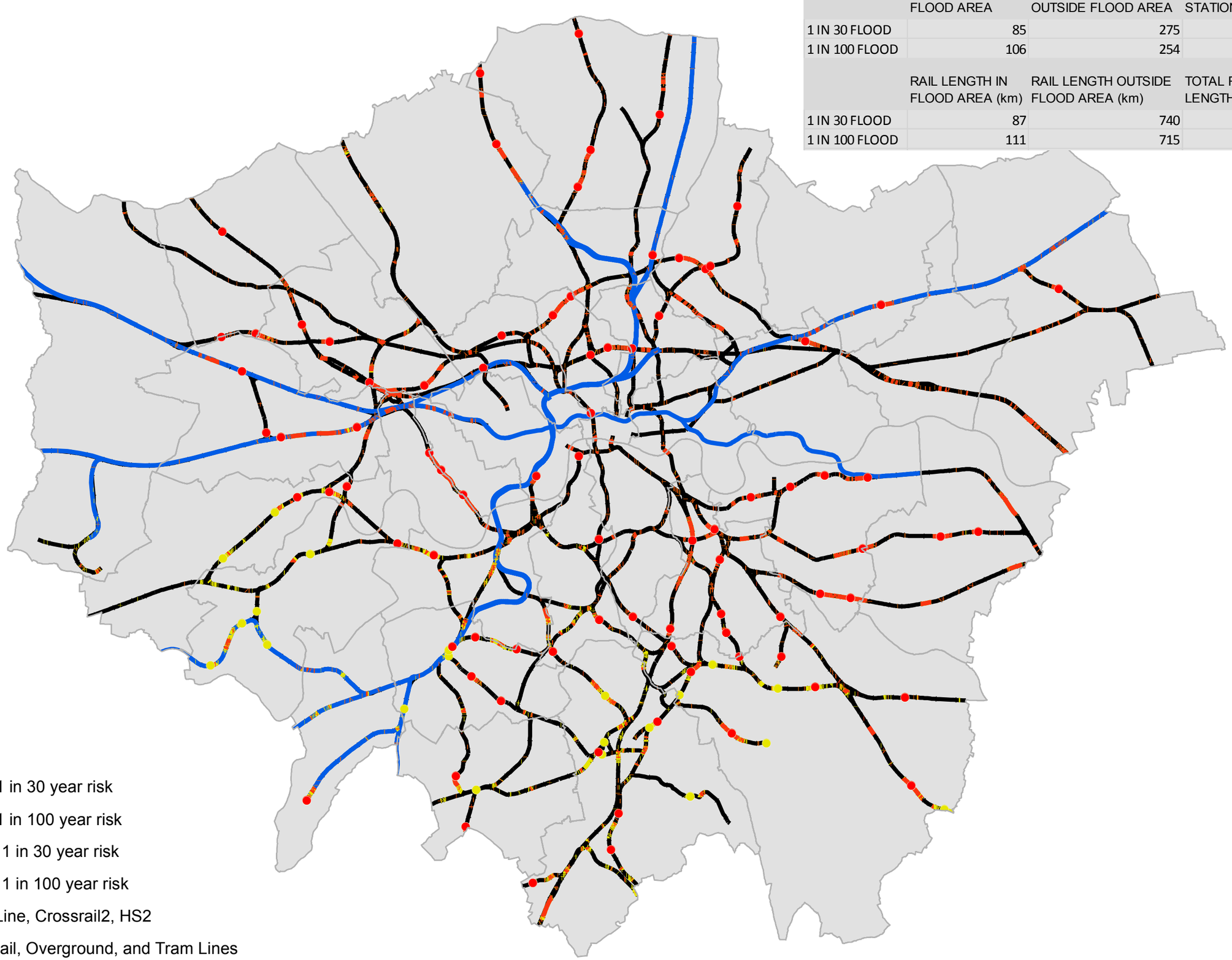
Town Centres and Flood Risk 2017

NAME	LP2016REF	CLASSIFICATION	1 IN 100 RISK AREA (Ha)	1 IN 30 RISK AREA (Ha)	TOTAL AREA 2016 (Ha)	PERCENT AT RISK 1 IN 30	PERCENT AT RISK 1 IN 100
Knightsbridge	2	International	0.8	0.5	11.2	4.5%	7.0%
West End	1	International	4.9	1.4	104.8	1.3%	4.6%
Bromley	3	Metropolitan	4.8	1.7	69.4	2.4%	6.9%
Croydon	4	Metropolitan	16.3	5.5	111.7	4.9%	14.6%
Ealing	5	Metropolitan	5.4	2.6	68.0	3.8%	8.0%
Harrow	8	Metropolitan	1.8	0.8	38.8	2.1%	4.7%
Hounslow	11	Metropolitan	2.3	0.9	34.5	2.5%	6.8%
Ilford	14	Metropolitan	2.0	0.7	54.8	1.3%	3.6%
Kingston	12	Metropolitan	31.3	26.8	79.2	33.8%	39.6%
Romford	9	Metropolitan	16.6	9.2	82.0	11.2%	20.2%
Shepherds Bush	6	Metropolitan	4.6	3.3	39.9	8.3%	11.5%
Stratford	13	Metropolitan	5.7	1.5	69.8	2.2%	8.2%
Sutton	15	Metropolitan	5.1	2.9	57.9	4.9%	8.8%
Uxbridge	10	Metropolitan	2.9	1.1	51.4	2.1%	5.6%
Wood Green	7	Metropolitan	2.3	0.8	20.9	3.9%	11.1%
Angel	31	Major	1.0	0.3	34.2	0.8%	3.0%
Barking	16	Major	0.9	0.3	25.9	1.0%	3.5%
Bexleyheath	18	Major	1.3	0.4	33.9	1.3%	3.8%
Brixton	35	Major	2.7	1.0	28.7	3.3%	9.3%
Camden Town	22	Major	2.3	1.0	27.9	3.7%	8.2%
Canary Wharf	43	Major	11.8	11.7	52.5	22.3%	22.4%
Catford	37	Major	7.1	1.4	24.9	5.7%	28.5%
Chiswick	30	Major	1.9	1.8	27.4	6.7%	7.0%
Clapham Junction	45	Major	2.3	1.4	22.8	6.2%	10.2%
Dalston	27	Major	1.1	0.4	16.2	2.5%	6.6%
East Ham	40	Major	0.8	0.4	15.6	2.3%	5.1%
Edgware	17	Major	3.3	1.8	20.9	8.8%	15.8%
Eltham	25	Major	0.9	0.6	38.7	1.6%	2.3%
Enfield Town	24	Major	1.3	0.5	21.8	2.2%	6.1%
Fulham	28	Major	1.2	1.1	16.5	6.8%	7.3%
Hammersmith	29	Major	8.1	8.0	34.4	23.3%	23.7%
Kensington High Street	33	Major	1.2	0.7	12.4	5.5%	9.5%
Kilburn	20	Major	1.6	0.8	16.6	5.1%	9.5%
King's Road (east)	34	Major	1.1	0.7	10.9	6.4%	10.3%
Lewisham	38	Major	19.1	6.9	36.3	19.1%	52.5%
Nags Head	32	Major	2.6	1.0	17.1	5.8%	15.3%
Orpington	21	Major	8.4	2.9	18.4	16.0%	45.6%
Peckham	42	Major	2.8	1.2	29.6	4.0%	9.5%
Putney	46	Major	2.5	1.3	21.4	5.9%	11.7%
Queensway/ Westbourne Grove	49	Major	1.2	0.3	6.6	4.4%	18.1%
Richmond	41	Major	2.2	1.0	28.6	3.6%	7.8%
Southall	23	Major	1.8	0.5	38.1	1.4%	4.7%
Streatham	36	Major	1.8	0.9	27.4	3.4%	6.7%
Tooting	47	Major	2.4	1.5	14.9	9.9%	16.0%
Walthamstow	44	Major	2.7	1.0	39.2	2.5%	6.8%
Wandsworth	48	Major	10.5	2.7	23.9	11.3%	44.0%
Wembley	19	Major	3.0	1.3	45.4	2.8%	6.7%
Wimbledon	39	Major	2.8	0.9	28.6	3.1%	9.7%
Woolwich	26	Major	29.9	26.6	100.2	26.6%	29.9%
TOTALS:							
International			5.6	1.9	116.1	1.6%	4.9%
Metropolitan			101.1	57.7	778.3	13.0%	7.4%
Major			145.6	84.5	958.1	8.8%	15.2%

Map 4 - Mainline Rail Network and Flood Risk 2017

	RAIL STATIONS IN FLOOD AREA	RAIL STATIONS OUTSIDE FLOOD AREA	TOTAL RAIL STATIONS	PORTION IN FLOOD ZONE
1 IN 30 FLOOD	85	275	360	24%
1 IN 100 FLOOD	106	254	360	29%

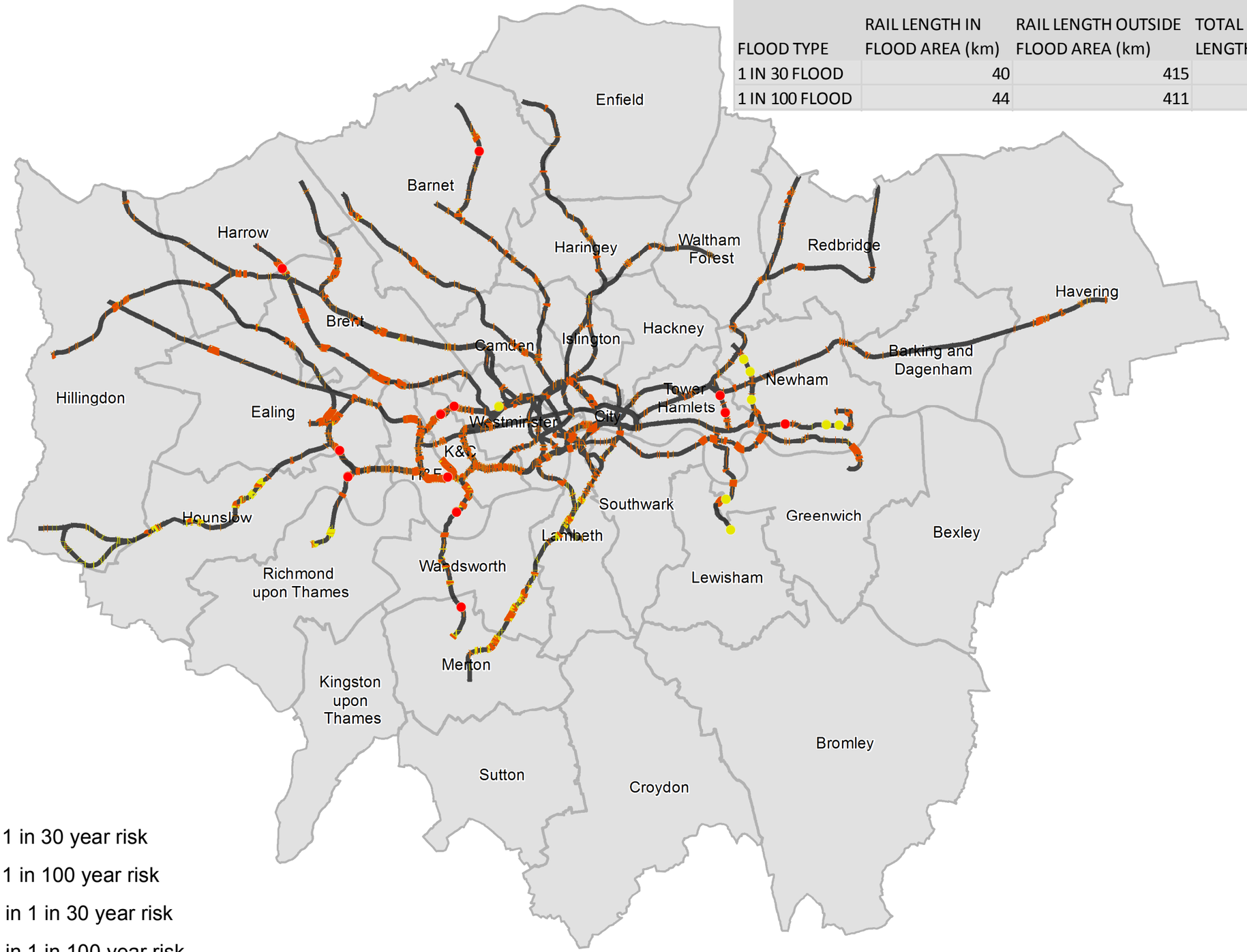
	RAIL LENGTH IN FLOOD AREA (km)	RAIL LENGTH OUTSIDE FLOOD AREA (km)	TOTAL RAIL LENGTH (km)	PORTION IN FLOOD ZONE
1 IN 30 FLOOD	87	740	827	11%
1 IN 100 FLOOD	111	715	827	13%



Map 5 - Underground and DLR Networks and Flood Risk 2017

FLOOD TYPE	RAIL STATIONS IN FLOOD AREA	RAIL STATIONS OUTSIDE FLOOD AREA	TOTAL RAIL STATIONS	PORTION IN FLOOD ZONE
1 IN 30 FLOOD	12	285	297	4%
1 IN 100 FLOOD	20	277	297	7%

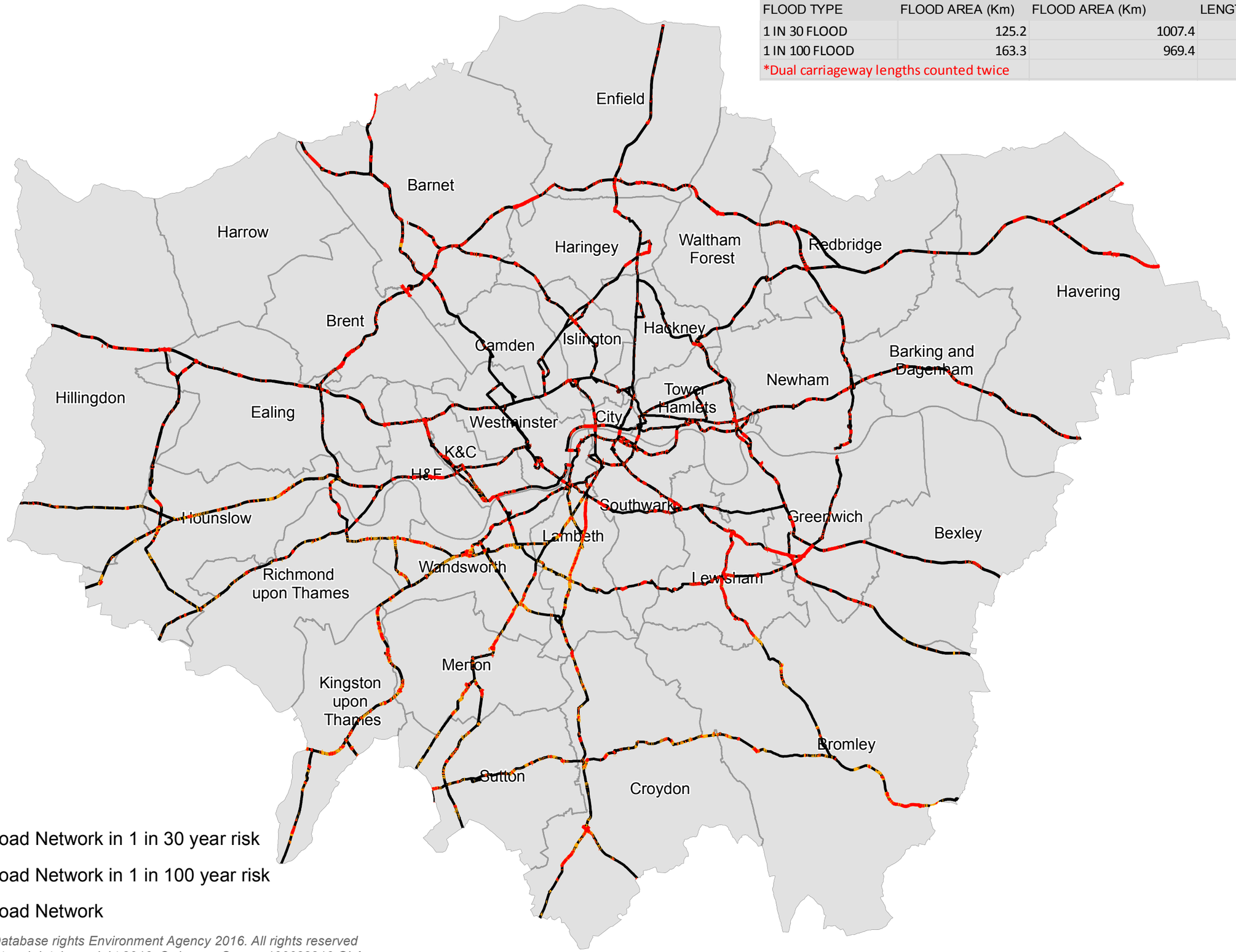
FLOOD TYPE	RAIL LENGTH IN FLOOD AREA (km)	RAIL LENGTH OUTSIDE FLOOD AREA (km)	TOTAL RAIL LENGTH (km)	PORTION IN FLOOD ZONE
1 IN 30 FLOOD	40	415	455	9%
1 IN 100 FLOOD	44	411	455	10%



- Underground Lines
- Underground Lines in 1 in 30 year risk
- Underground Lines in 1 in 100 year risk
- Underground Stations in 1 in 30 year risk
- Underground Stations in 1 in 100 year risk

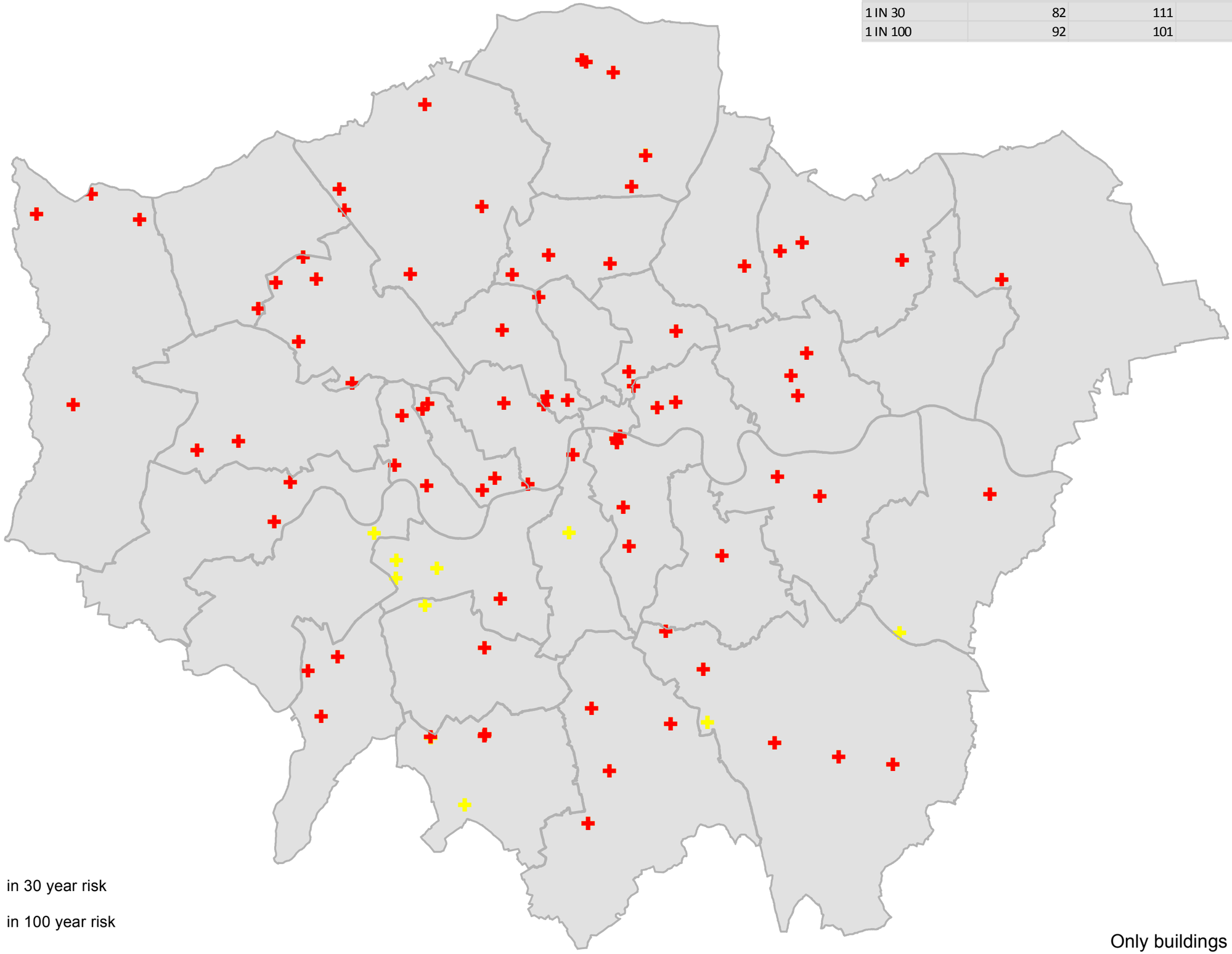
Map 6 - TfL Road Network and Flood Risk 2017

FLOOD TYPE	ROADS LENGTH IN FLOOD AREA (Km)	ROADS LENGTH OUTSIDE FLOOD AREA (Km)	TOTAL ROAD LENGTH (Km)	PORTION IN FLOOD ZONE
1 IN 30 FLOOD	125.2	1007.4	1132.7	11%
1 IN 100 FLOOD	163.3	969.4	1132.7	14%
*Dual carriageway lengths counted twice				



Map 7 - Hospitals and Flood Risk 2017

Flood Area Type	Number in Flood Area	Number Outside Flood Area	Total Number in Greater London	Percent in Flood Area
1 IN 30	82	111	193	42%
1 IN 100	92	101	193	48%



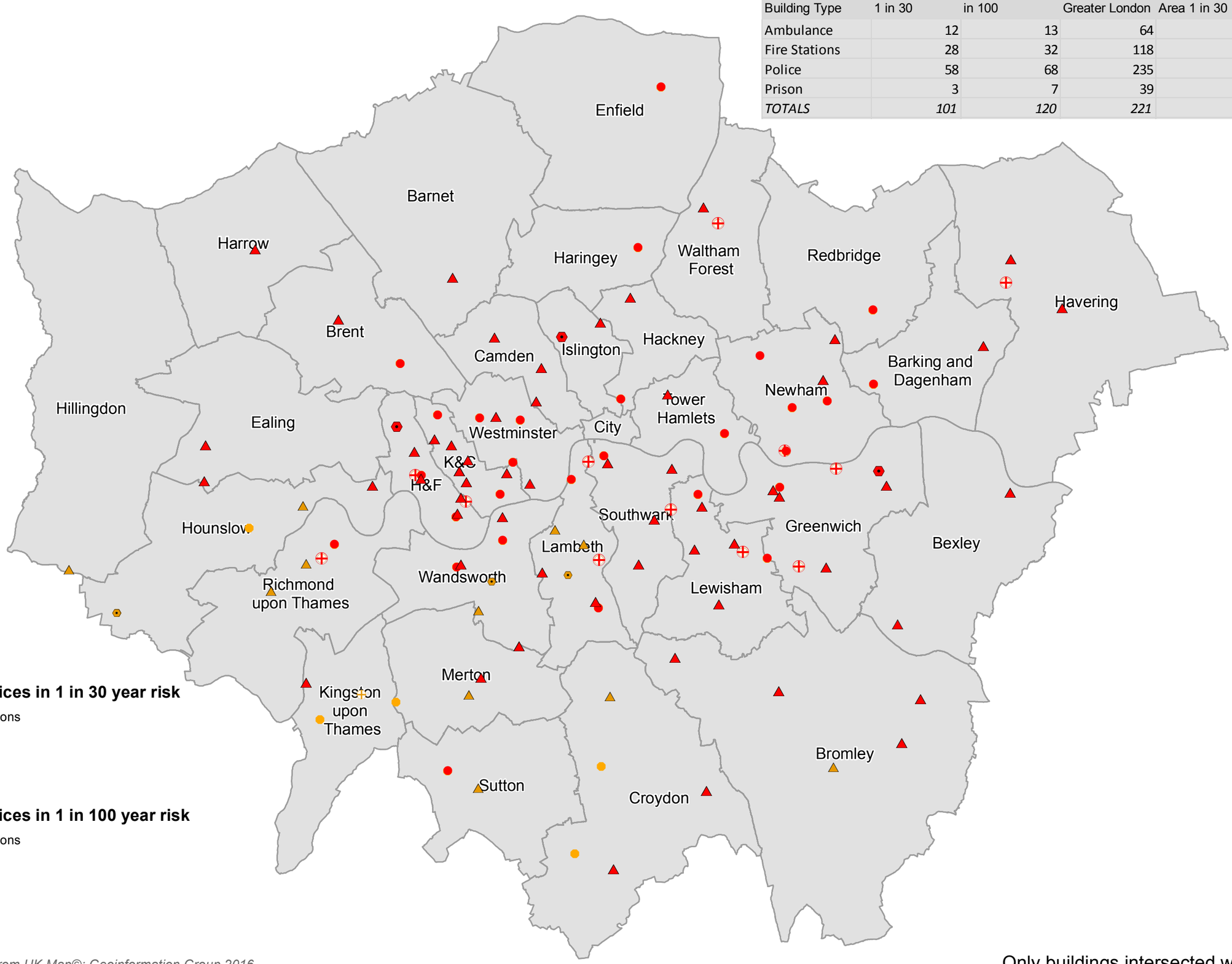
Hospitals 1 in 30 year risk

Hospitals 1 in 100 year risk

Only buildings intersected with flood risk map

Map 8 - Emergency Services and Flood Risk 2017

Emergency Building Type	Number inside 1 in 30	Number inside 1 in 100	Total Number in Greater London	Percent in Flood Area 1 in 30	Percent in Flood Area 1 in 100
Ambulance	12	13	64	19%	20%
Fire Stations	28	32	118	24%	27%
Police	58	68	235	25%	29%
Prison	3	7	39	8%	18%
TOTALS	*101*	*120*	*221*	*23%*	*27%*



Emergency Services in 1 in 30 year risk

- Ambulance stations
- Fire station
- Police station
- Prison

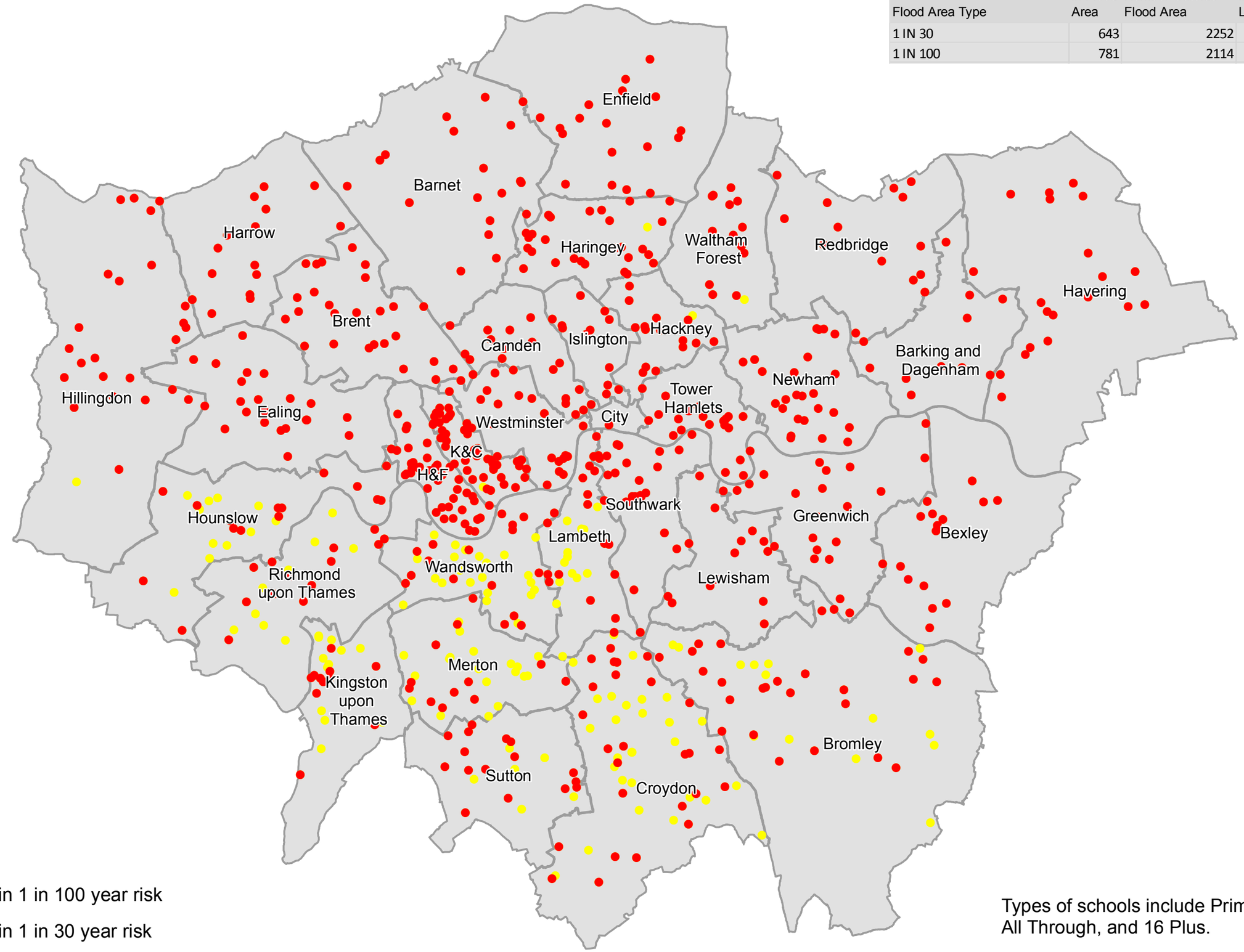
Emergency Services in 1 in 100 year risk

- Ambulance stations
- Fire station
- Police station
- Prison

Only buildings intersected with flood risk map

Map 9 - Schools and Flood Risk 2017

Flood Area Type	Number in Flood Area	Number Outside Flood Area	Total Number in Greater London	Percent in Flood Area
1 IN 30	643	2252	2895	22%
1 IN 100	781	2114	2895	27%



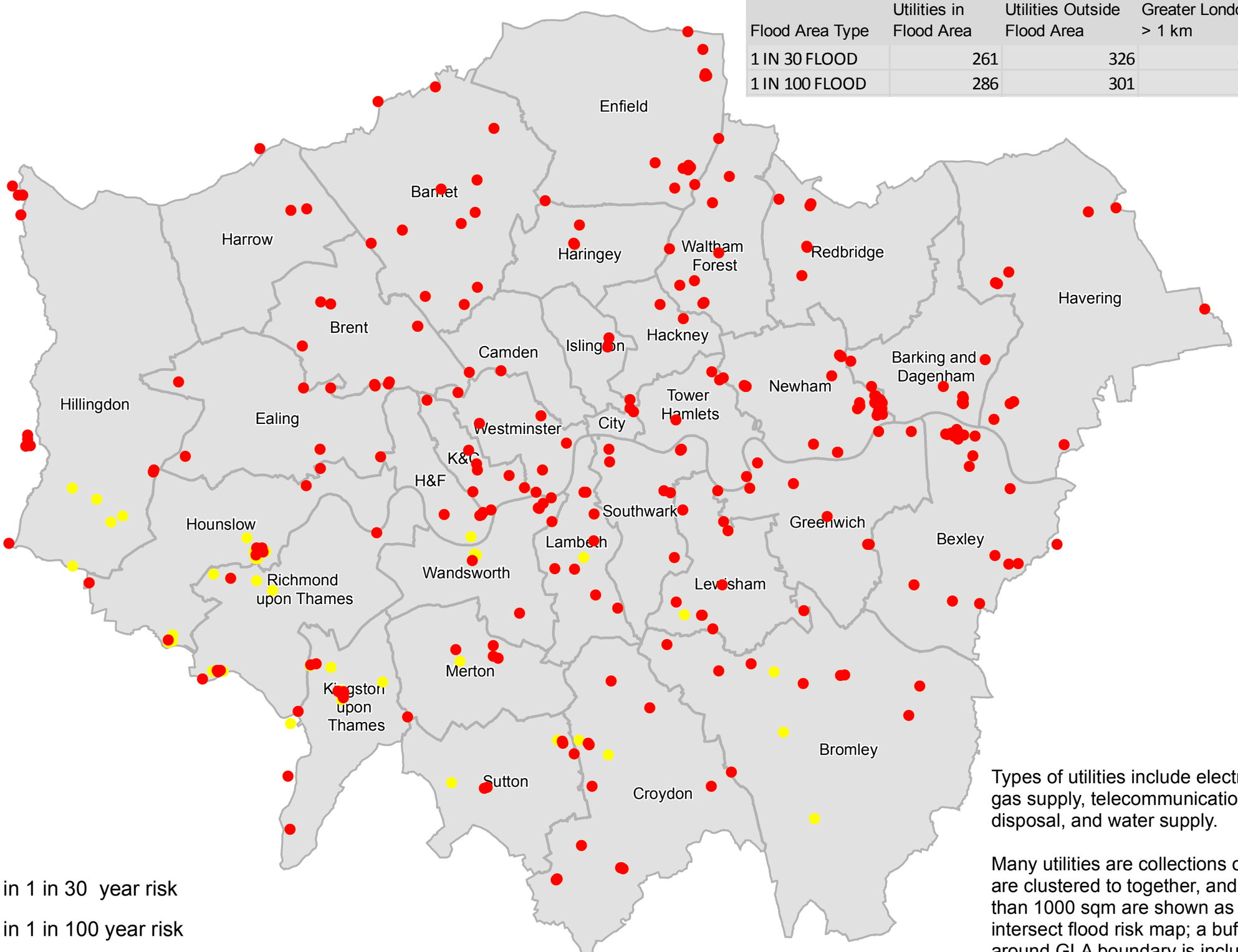
- Schools in 1 in 100 year risk
- Schools in 1 in 30 year risk

Types of schools include Primary, Secondary, All Through, and 16 Plus.

Only buildings intersected with flood risk map.

Map 10 - Utilities Infrastructure and Flood Risk 2017

Flood Area Type	Utilities in Flood Area	Utilities Outside Flood Area	Total Number in Greater London > 1 km	Percent in Flood Area
1 IN 30 FLOOD	261	326	587	44%
1 IN 100 FLOOD	286	301	587	49%



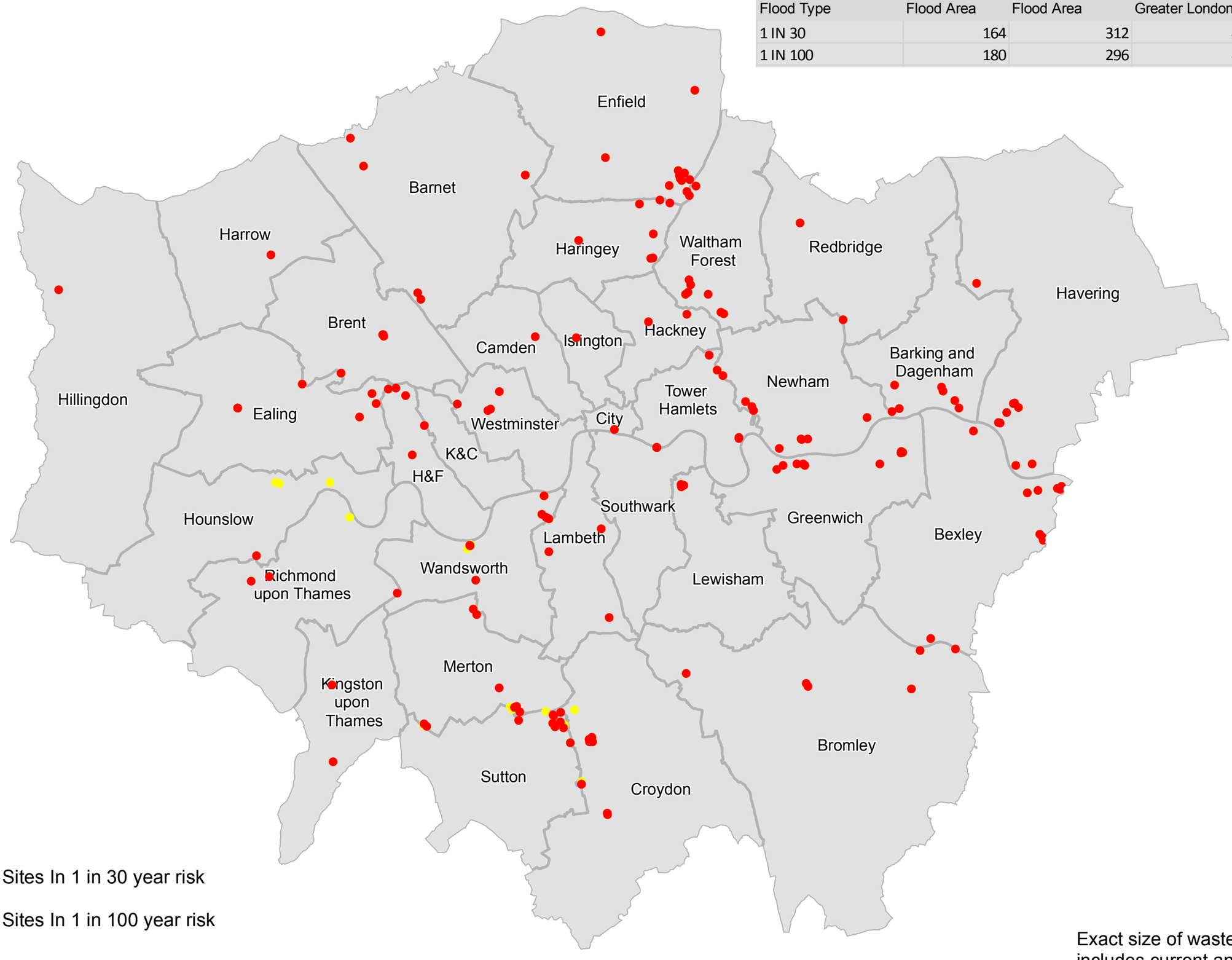
- Utilities in 1 in 30 year risk
- Utilities in 1 in 100 year risk

Types of utilities include electricity supply, gas supply, telecommunications, sewage disposal, and water supply.

Many utilities are collections of buildings and are clustered to together, and those greater than 1000 sqm are shown as points, if they intersect flood risk map; a buffer of 1 km around GLA boundary is included, as several utilities cross this boundary

Map 11 - Waste or Treatment Sites and Flood Risk 2017

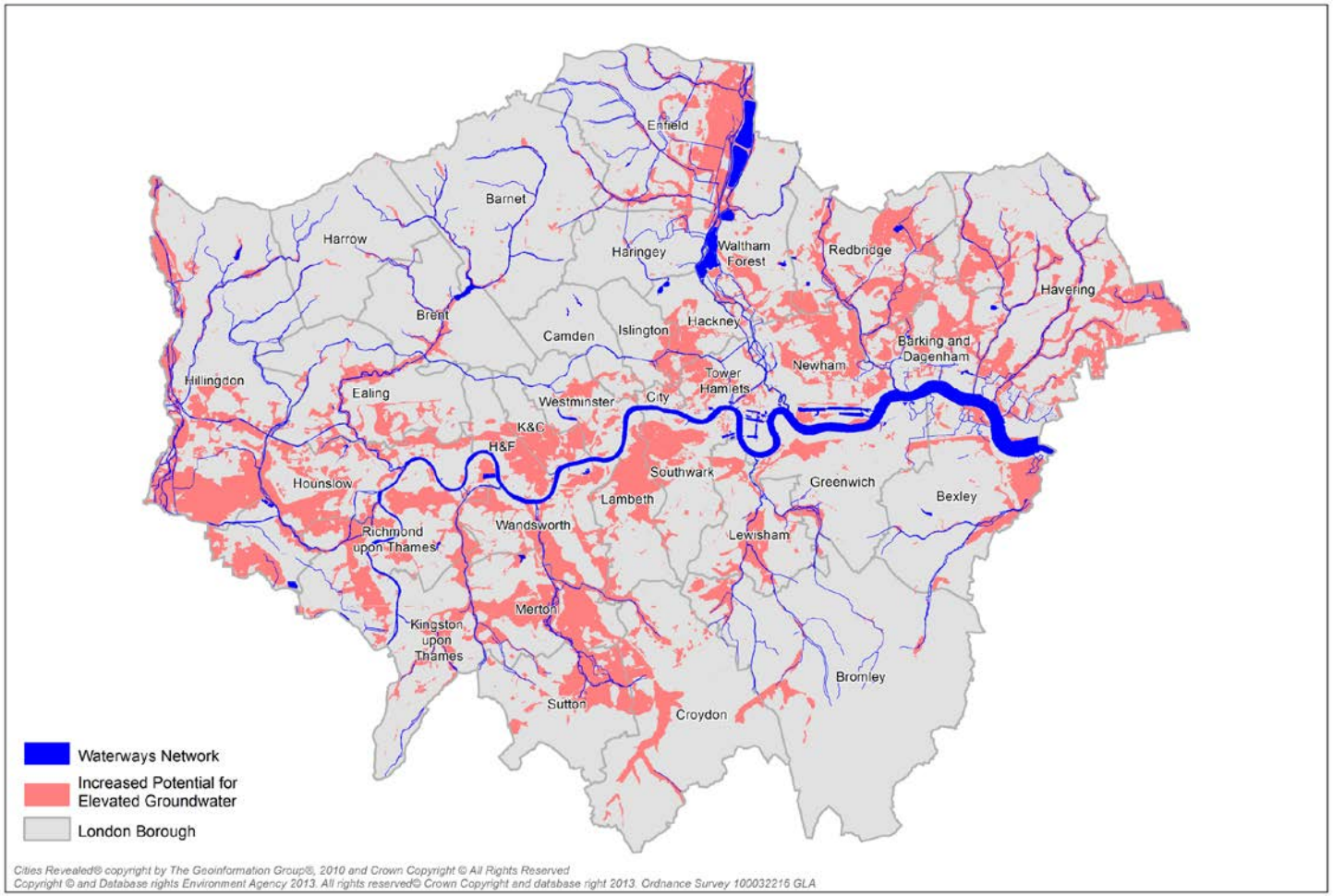
Flood Type	Number in Flood Area	Number Outside Flood Area	Total Number in Greater London	Percent in Flood Area
1 IN 30	164	312	476	34%
1 IN 100	180	296	476	38%



- Waste Sites In 1 in 30 year risk
- Waste Sites In 1 in 100 year risk

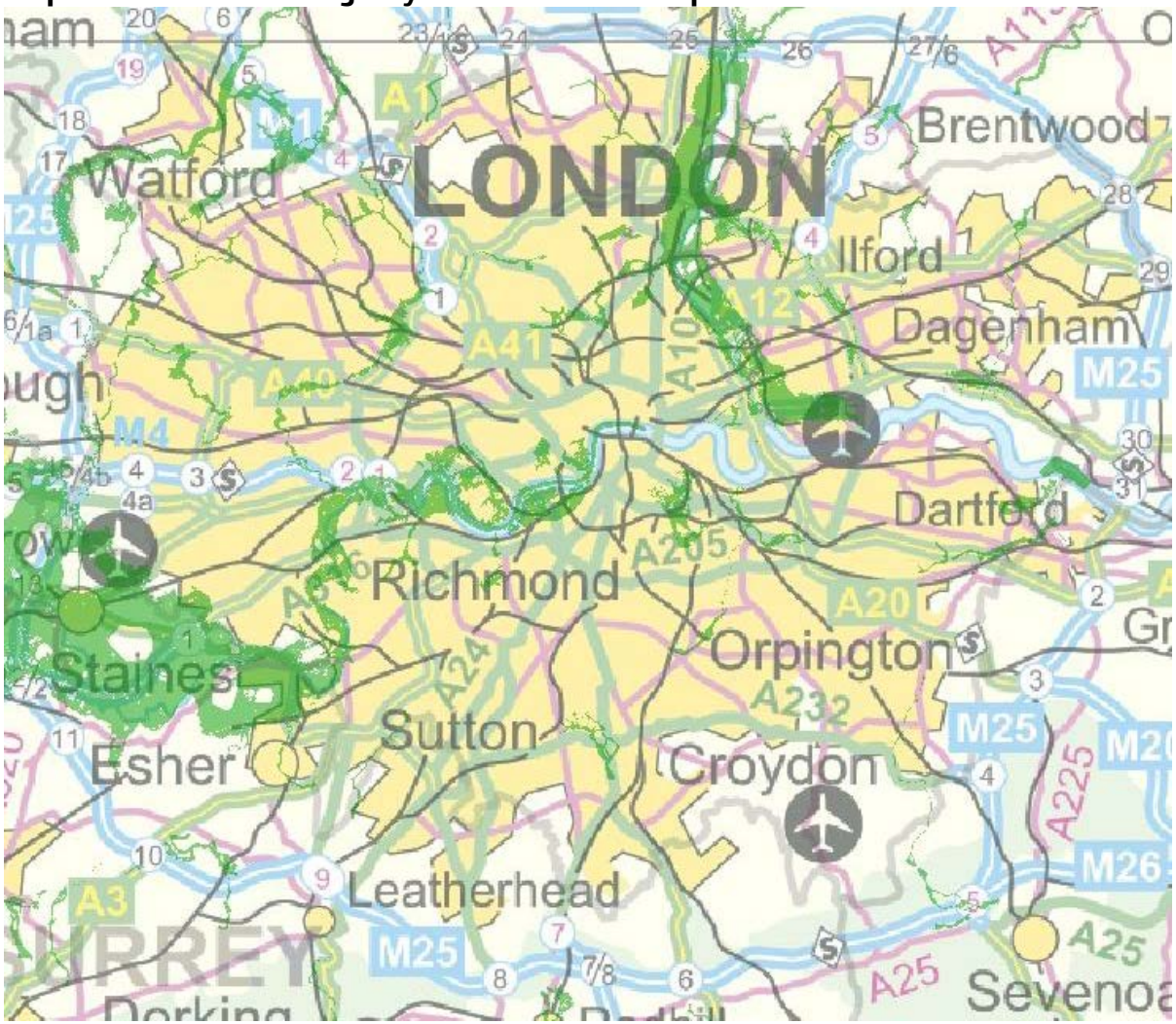
Exact size of waste sites estimated; includes current and proposed sites

Map 12 – Increased Potential for Elevated Groundwater



Source: GLA

Map 13 – Environment Agency Reservoir Flood Map – London extract illustration



Source: Environment Agency